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Ballistic Evaluation of 7056 Aluminum

by Denver B Gallardy

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Weapons and Materials Research Directorate, ARL

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14. ABSTRACT <p>The US Army Research Laboratory evaluated the ballistic performance of aluminum alloys (AAs) 7056-T761, 7056-T751, and 7056-T721 produced by Constellium. Ballistic evaluation was performed using armor-piercing and fragment-simulating projectiles to determine the V_{50} ballistic-protection limit (V_{50}) for various thicknesses of material. The V_{50} was then compared with other ballistic-grade AAs, namely AA7085-T711 and AA7085-T721. The results of these experiments were used to validate the acceptance tables for AA7085 and AA7056 included in the updated military specification, MIL-DTL-32375A (MR).</p>					
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1. Introduction

Aluminum alloy (AA) 7056 is Constellium's next-generation armor offering that can be sourced both domestically and through North Atlantic Treaty Organization member countries. Two tempers were developed: 1) a high-strength variant, 7056-T761, for use as an appliqué against direct-fire threats and 2) a lower strength, higher ductility variant, 7056-T721, for underbody blast protection kits. AA7056-T761 is currently in competition to be used in several Army platforms including the Bradley, Joint Light Tactical Vehicle, and Armored Multi-Purpose Vehicle.

The ballistics goal of this program was to verify that AA7056-T761 and AA7056-T721 met or exceeded the performance of comparable military-specification (mil-spec) 7XXX-series alloy produced by Alcoa, namely 7085-T711 and 7085-T721.¹ The results were used to subsequently add 7056 to the 7085 specification, allowing increased availability of material and pricing competition to benefit the Army. In addition to the 2 tempers outlined for the mil-spec, a third temper, 7056-T751, was also assessed. AA7056-T751 was the original blast temper but was modified slightly during the evaluation period warranting the updated 7056-T721 designation. The properties of the 7056-T751 evaluated were very similar to the 7056-T721 temper, and therefore the data were combined during analysis. Table 1 outlines the average mechanical properties for the evaluated samples.

Table 1 Average mechanical properties of evaluated plates

Alloy/ temper	Direction	Ultimate tensile strength (MPa)	Yield strength, 0.2% offset (MPa)	Elongation (%)	Direction	Ultimate tensile strength (MPa)	Yield strength, 0.2% offset (MPa)	Elongation (%)
7056-T721	L	495.8	446.8	15.0	LT	497.1	442.0	12.9
7056-T751	L	494.5	455.2	14.5	LT	510.3	457.3	12.3
7056-T761	L	568.8	547.5	11.5	LT	573.9	541.0	9.9

Note: L = longitudinal; LT = long transverse

Several thicknesses of the temper variants were provided to the US Army Research Laboratory (ARL) by Constellium. Table 2 is a summary matrix of the evaluated thicknesses subjected to impacts from various munitions including armor-piercing (AP) and fragment-simulating projectiles (FSPs). Additionally, Table 3 provides the required chemistries for AA7056 as well as other common aluminum (Al) armor alloys.

Table 2 Experimental matrix for the AA7056 tempers indicating the number of plates evaluated

Nominal plate gage (mm)	0.30-cal. APM2 0°		0.50-cal. APM2 0°		14.5-mm BS41 0°		0.50-cal. FSP 0°		20-mm FSP 0°	
	obliquity		obliquity		obliquity		obliquity		obliquity	
	T761	T721/ T751	T761	T721/ T751	T761	T721/ T751	T761	T721/ T751	T761	T721/ T751
22.23	1	2	...	...	...	...	1	2	1	2
25.40	1	1	...	...	...	...	...	1	1	1
38.10	3	2	2	5	...	...	...	...	3	2
41.28	...	2	...	...	...	...	...	...	...	2
50.80	...	...	1	1	...	...	...	...	...	...
57.15	...	...	...	...	...	...	...	...	...	...
63.50	...	...	2	4	2	4	...	...	...	...
76.20	...	...	...	2	1	2	...	...	...	...

Table 3 Chemistry of AAs, weight-percent ranges²

Element	5083	6061	2139	2195	2060	7017	7085	7056
Copper	0.10 max	0.15–0.40	4.5–5.5	3.70–4.30	3.40–4.50	0.20 max	1.3–2.0	1.2–1.9
Iron	0.40 max	0.70 max	0.15 max	0.15 max	0.07 max	0.45 max	0.08 max	0.12 max
Lithium	...	...	...	0.80–1.20	0.60–0.90	...	...	...
Chromium	0.05–0.25	0.04–0.35	0.05 max	...	...	0.35 max	0.04 max	...
Manganese	0.40–1.0	0.15 max	0.20–0.60	0.25 max	0.10–0.50	0.05–0.50	0.04 max	0.20 max
Magnesium	4.0–4.90	0.8–1.2	0.20–0.80	0.25–0.80	0.60–1.10	2.0–3.0	1.2–1.8	1.5–2.3
Silicon	0.40 max	0.40–0.80	0.10 max	0.12 max	0.07 max	0.35 max	0.06 max	0.10 max
Titanium	0.15 max	0.15 max	0.15 max	0.10 max	0.10 max	0.15 max	0.06 max	0.08 max
Zinc	0.25 max	0.25 max	0.25 max	0.25 max	0.30–0.50	4.0–5.2	7.0–8.0	8.5–9.7
Zirconium	...	...	...	0.08–0.16	0.05–0.15	0.10–0.25	0.08–0.15	0.05–0.15
Silver	...	...	0.15–0.60	0.25–0.60	0.05–0.50	...	...	...
Others (each)	0.05 max	0.05 max	0.05 max	0.05 max	0.05 max	0.05 max	0.05 max	0.05 max
Others (total)	0.15 max	0.15 max	0.15 max	0.15 max	0.15 max	0.15 max	0.15 max	0.15 max
Aluminum	Remainder	Remainder	Remainder	Remainder	Remainder	Remainder	Remainder	Remainder

2. Experimental Procedure

The V_{50} is defined as the impact velocity at which the projectile is equally as likely to perforate the target as it is to be arrested. A 0.51-mm (0.020 inch) 2024 T3 Al witness plate was positioned 152 mm (6 inches) behind the target to determine the outcome of each shot. An impact is regarded as a complete penetration (CP), or loss, if the projectile or a resulting target fragment from impact creates a hole in the witness plate through which light can be observed. If an impact does not result in a CP, it is considered a partial penetration (PP), or win. To keep results as consistent as possible, only shots conforming to the following conditions were used to determine the V_{50} : The projectile must be unyawed—less than 2° of total yaw for AP rounds and less than 5° of total yaw for FSPs—and strike the target at least 2 projectile diameters from any previous impact or damage or the edge of the target. Total yaw is defined as the vector sum of the projectile's pitch and yaw. The V_{50} is calculated by the arithmetic mean of an equal number of CPs and PPs within an 18-m/s (60 ft/s) spread for a $2 + 2 V_{50}$, a 27-m/s (90 ft/s) spread for a $3 + 3 V_{50}$, and as small of a spread as attainable for a $5 + 5 V_{50}$.³

Projectile velocities for the determination of the V_{50} were measured using one of 2 methods, as shown in Fig. 1. The first method is an orthogonal flash X-ray system, described in detail by Grabarek and Herr,⁴ that also measures pitch and yaw. The second method uses 3 IR screens and a chronograph. The velocity is calculated using the first and third screens with the middle screen used to check for bad readings. The flash X-ray method was used in situations with projectiles that historically exhibit excessive yaw or if space did not allow for the use of the IR break screens. When the IR break screens and chronograph were used, the projectile velocity was corrected to the target-impact location using a correction factor based on an initial flash X-ray reading at the impact location. The correction was made using Eqs. 1 and 2 in lieu of using air-drag factors.

$$\frac{(\text{x-ray velocity})}{(\text{chronograph velocity})} = (\text{correction factor}). \quad (1)$$

$$(\text{correction factor}) \times (\text{chronograph velocity}) = (\text{corrected velocity}). \quad (2)$$

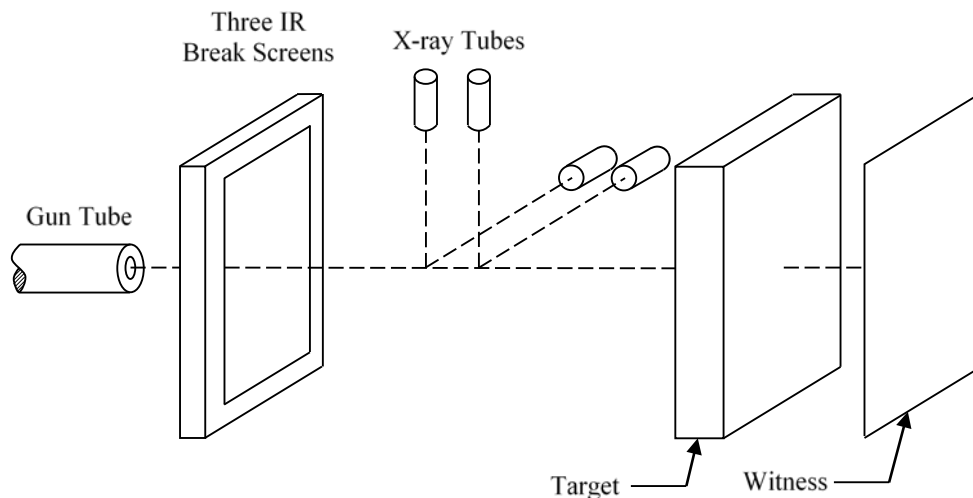


Fig. 1 Typical experimental setup

3. Experimental Projectiles

3.1 Armor-Piercing Projectiles

The US 0.30-cal. APM2 and 0.50-cal. APM2 plus the Soviet 14.5-mm BS41 are the 3 AP projectiles that were used in this study. These projectiles are shown in Fig 2. The APM2 projectiles have hardened steel cores with a Rockwell hardness of C61-63, whereas the BS41 has a tungsten carbide core. The physical characteristics of these projectiles are listed in Table 4.

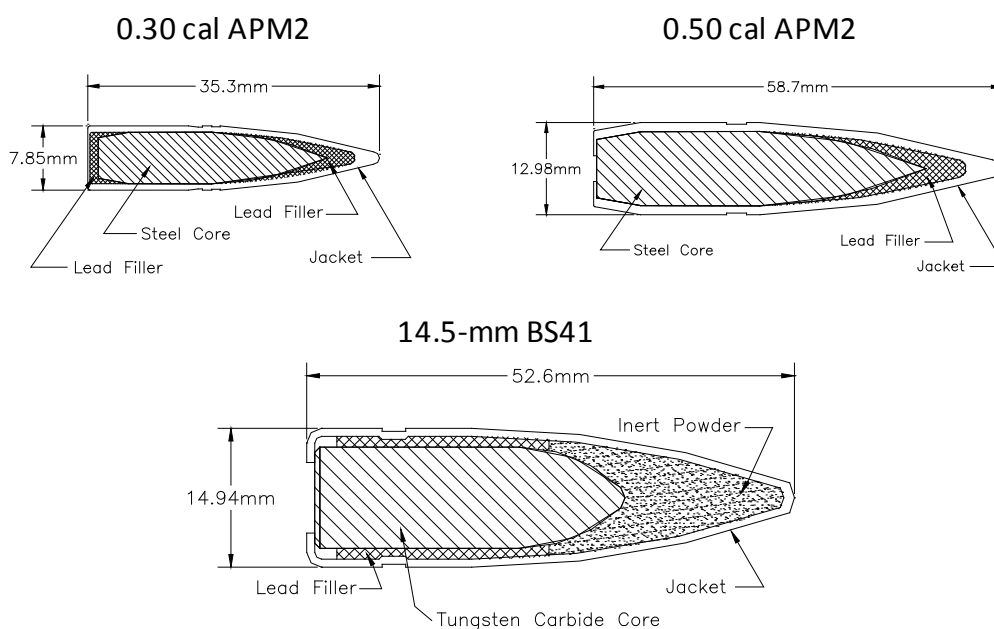


Fig. 2 AP projectiles

Table 4 AP projectiles' physical characteristics⁵

Projectile type	Projectile			Core		
	Length (mm)	Diameter (mm)	Weight (g)	Length (mm)	Diameter (mm)	Weight (g)
0.30-cal. APM2	35.3	7.85	10.8	27.4	6.2	5.3
0.50-cal. APM2	58.7	12.98	45.9	47.5	10.9	25.9
14.5-mm BS41	52.6	14.94	63.2	32.3	10.9	37.9

3.2 Fragment-Simulating Projectiles

FSPs (Fig. 3) are a family of projectiles that are flat-nosed, right circular cylinders manufactured to MIL-DTL-46593B (MR).⁶ These projectiles are used in material evaluations and acceptance testing to simulate performance against fragments produced from improvised explosive devices and artillery. Both 0.50-cal. and 20-mm FSPs were used for the evaluation of AA7056.

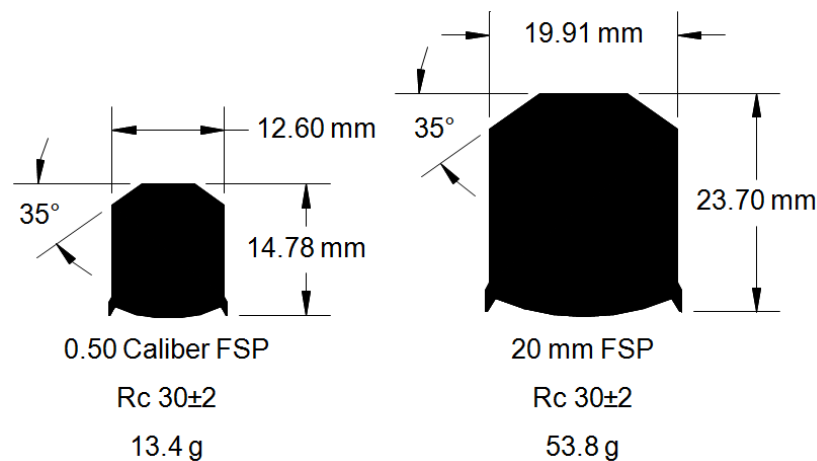


Fig. 3 FSP projectiles

4. Results and Analysis

The experimental results are summarized in Tables 5–14. The individual shot records are provided in Appendix A and Appendix B.

Table 5 APM2 0.30-cal., 0° obliquity V₅₀ ballistic limits for AA7056-T761

Plate ID	Nominal thickness		Actual thickness		Areal density		V ₅₀		Standard deviation	
	(mm)	(inches)	(mm)	(inches)	(kg/m ²)	(lb/ft ²)	(m/s)	(ft/s)	(m/s)	(ft/s)
823551	22.23	0.88	22.68	0.893	65.10	13.33	677	2221	7	23
823551	25.40	1.00	28.02	1.103	80.41	16.47	764	2508	7	22
823531	38.10	1.50	36.75	1.447	105.48	21.60	893	2931	8	26
900305	38.10	1.50	37.77	1.487	108.40	22.20	906	2972	5	18
823531	38.10	1.50	40.59	1.598	116.49	23.86	939	3081	6	22

Table 6 APM2 0.50-cal., 0° obliquity V₅₀ ballistic limits for AA7056-T761

Plate ID	Nominal thickness		Actual thickness		Areal density		V ₅₀		Standard deviation	
	(mm)	(inches)	(mm)	(inches)	(kg/m ²)	(lb/ft ²)	(m/s)	(ft/s)	(m/s)	(ft/s)
823531	38.10	1.50	36.75	1.447	105.48	21.60	656	2153	8	25
900305	38.10	1.50	37.77	1.487	108.40	22.20	651	2135	5	15
823531	38.10	1.50	40.64	1.600	116.64	23.89	692	2271	6	20
900294	50.80	2.00	49.28	1.940	141.42	28.97	776	2545	5	17
823541	63.50	2.50	65.23	2.568	187.20	38.34	916	3006	7	22
823561	63.50	2.50	65.35	2.573	187.57	38.42	928	3046	6	20

Table 7 14.5-mm BS41, 0° obliquity V₅₀ ballistic limits for AA7056-T761

Plate ID	Nominal thickness		Actual thickness		Areal density		V ₅₀		Standard deviation	
	(mm)	(inches)	(mm)	(inches)	(kg/m ²)	(lb/ft ²)	(m/s)	(ft/s)	(m/s)	(ft/s)
823541	63.50	2.50	65.20	2.567	187.13	38.33	846	2777	6	19
823561	63.50	2.50	65.35	2.573	187.57	38.42	860	2823	5	17
900293	76.20	3.00	77.60	3.055	222.70	45.61	934	3065	8	26

Table 8 FSP 0.50-cal., 0° obliquity V₅₀ ballistic limits for AA7056-T761

Plate ID	Nominal thickness		Actual thickness		Areal density		V ₅₀		Standard deviation	
	(mm)	(inches)	(mm)	(inches)	(kg/m ²)	(lb/ft ²)	(m/s)	(ft/s)	(m/s)	(ft/s)
823551	22.23	0.88	22.68	0.893	65.10	13.33	846	2774	5	19

Table 9 FSP 20-mm, 0° obliquity V₅₀ ballistic limits for AA7056-T761

Plate ID	Nominal thickness		Actual thickness		Areal density		V ₅₀		Standard deviation	
	(mm)	(inches)	(mm)	(inches)	(kg/m ²)	(lb/ft ²)	(m/s)	(ft/s)	(m/s)	(ft/s)
823551	22.23	0.88	22.68	0.893	65.10	13.33	360	1180	14	45
823551	25.40	1.00	28.02	1.103	80.41	16.47	522	1711	4	15
823531	38.10	1.50	36.75	1.447	105.48	21.60	870	2854	7	23
900305	38.10	1.50	37.77	1.487	108.40	22.20	880	2887	7	23
823531	38.10	1.50	40.59	1.598	116.49	23.86	986	3234	4	14

Table 10 APM2 0.30-cal., 0° obliquity V₅₀ ballistic limits for AA7056-T751 and AA7056-T721

Plate ID	Plate temper	Nominal thickness		Actual thickness		Areal density		V ₅₀		Standard deviation	
		(mm)	(inches)	(mm)	(inches)	(kg/m ²)	(lb/ft ²)	(m/s)	(ft/s)	(m/s)	(ft/s)
649471	T721	22.23	0.88	22.66	0.892	65.03	13.32	659	2161	5	18
647911	T751	22.23	0.88	22.86	0.900	65.61	13.44	629	2065	7	21
647911	T751	25.40	1.00	26.01	1.024	74.65	15.29	691	2268	6	19
649461	T721	38.10	1.50	36.70	1.445	105.34	21.57	839	2753	7	24
647921	T751	38.10	1.50	36.80	1.449	105.63	21.63	853	2797	5	15
649461	T721	41.28	1.63	40.97	1.613	117.58	24.08	893	2929	6	19
647921	T751	41.28	1.63	41.61	1.638	119.41	24.46	922	3023	8	25

Table 11 APM2 0.50-cal., 0° obliquity V₅₀ ballistic limits for AA7056-T751 and AA7056-T721

Plate ID	Plate temper	Nominal thickness		Actual thickness		Areal density		V ₅₀		Standard deviation	
		(mm)	(inches)	(mm)	(inches)	(kg/m ²)	(lb/ft ²)	(m/s)	(ft/s)	(m/s)	(ft/s)
649461	T721	38.10	1.50	36.70	1.445	105.34	21.57	625	2050	8	24
647921	T751	38.10	1.50	36.80	1.449	105.63	21.63	636	2086	8	26
649461	T721	38.10	1.50	40.97	1.613	117.58	24.08	660	2167	7	22
647921	T751	38.10	1.50	41.61	1.638	119.41	24.46	676	2218	9	30
900306	T721	50.80	2.00	50.22	1.977	144.12	29.52	754	2473	8	25
933181	T751	63.50	2.50	62.05	2.443	178.09	36.48	851	2792	7	22
933181	T751	63.50	2.50	63.37	2.495	181.88	37.25	867	2845	9	29
936221	T721	63.50	2.50	65.25	2.569	187.27	38.36	879	2882	9	29
936231	T721	63.50	2.50	65.33	2.572	187.49	38.40	856	2809	10	32
933171	T751	76.20	3.00	74.68	2.940	214.32	43.90	945	3102	6	20
933171	T751	76.20	3.00	76.35	3.006	219.13	44.88	951	3121	4	12

Table 12 14.5-mm BS41, 0° obliquity V₅₀ ballistic limits for AA7056-T751 and AA7056-T721

Plate ID	Plate temper	Nominal thickness		Actual thickness		Areal density		V ₅₀		Standard deviation	
		(mm)	(inches)	(mm)	(inches)	(kg/m ²)	(lb/ft ²)	(m/s)	(ft/s)	(m/s)	(ft/s)
933181	T751	63.50	2.50	62.05	2.443	178.09	36.48	800	2624	6	21
933181	T751	63.50	2.50	63.37	2.495	181.88	37.25	819	2686	7	21
936221	T721	63.50	2.50	65.25	2.569	187.27	38.36	809	2652	3	11
936231	T721	63.50	2.50	65.33	2.572	187.49	38.40	817	2680	6	19
933171	T751	76.20	3.00	74.68	2.940	214.32	43.90	873	2866	8	25
933171	T751	76.20	3.00	76.35	3.006	219.13	44.88	894	2932	6	20

Table 13 FSP 0.50-cal., 0° obliquity V₅₀ ballistic limits for AA7056-T751 and AA7056-T721

Plate ID	Plate temper	Nominal thickness		Actual thickness		Areal density		V ₅₀		Standard deviation	
		(mm)	(inches)	(mm)	(inches)	(kg/m ²)	(lb/ft ²)	(m/s)	(ft/s)	(m/s)	(ft/s)
649471	T721	22.23	0.88	22.71	0.894	65.17	13.35	957	3140	5	18
647911	T751	22.23	0.88	22.86	0.900	65.61	13.44	799	2623	18	60
647911	T751	25.40	1.00	26.01	1.024	74.65	15.29	1100	3607	5	18

Table 14 FSP 20-mm, 0° obliquity V₅₀ ballistic limits for AA7056-T751 and AA7056-T721

Plate ID	Plate temper	Nominal thickness		Actual thickness		Areal density		V ₅₀		Standard deviation	
		(mm)	(inches)	(mm)	(inches)	(kg/m ²)	(lb/ft ²)	(m/s)	(ft/s)	(m/s)	(ft/s)
649471	T721	22.23	0.88	22.66	0.892	65.03	13.32	405	1329	7	23
647911	T751	22.23	0.88	22.86	0.900	65.61	13.44	394	1294	8	25
647911	T751	25.40	1.00	26.01	1.024	74.65	15.29	456	1495	6	21
649461	T721	38.10	1.50	36.70	1.445	105.34	21.57	874	2868	7	22
647921	T751	38.10	1.50	36.80	1.449	105.63	21.63	756	2479	11	35
649461	T721	41.28	1.63	40.97	1.613	117.58	24.08	1029	3376	8	27
647921	T751	41.28	1.63	41.61	1.638	119.41	24.46	1012	3319	2	8

The results of the ballistic evaluation are compared directly against the ballistic performance of AA7085. Figures 4–8 show the AA7056 ballistic data collected by ARL compared with previous AA7085 data.⁷ The data displayed are the V_{50} 's as a function of the plate thickness. Figures 9–13 show the AA7056 ballistic data as compared with the updated 7056/7085 specification MIL-DTL-32375A.¹ In instances where the acceptance curve has changed from the original document (MIL-DTL-32375), the original acceptance curve is shown for reference. Note that the plates are compared on a thickness basis to be consistent with the specifications; however, the densities of the alloys vary slightly. AA7056 has a density of 2.87 g/cm³, whereas AA7085 has a density of 2.85 g/cm³.

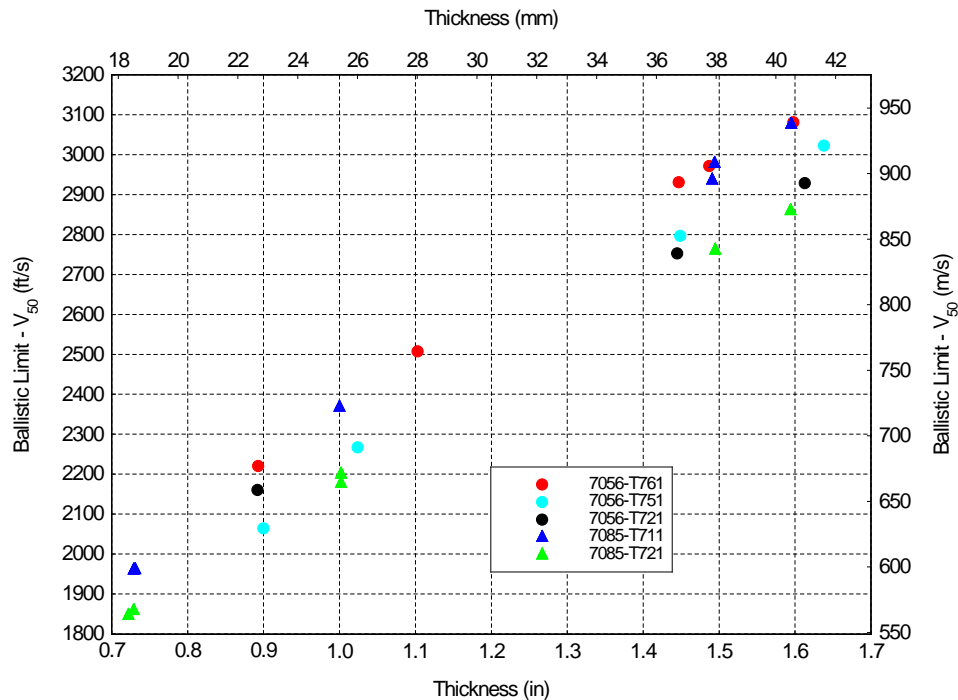


Fig. 4 Ballistic limit vs. thickness of AA7056 and AA7085 for the 0.30-cal. APM2 at 0° obliquity

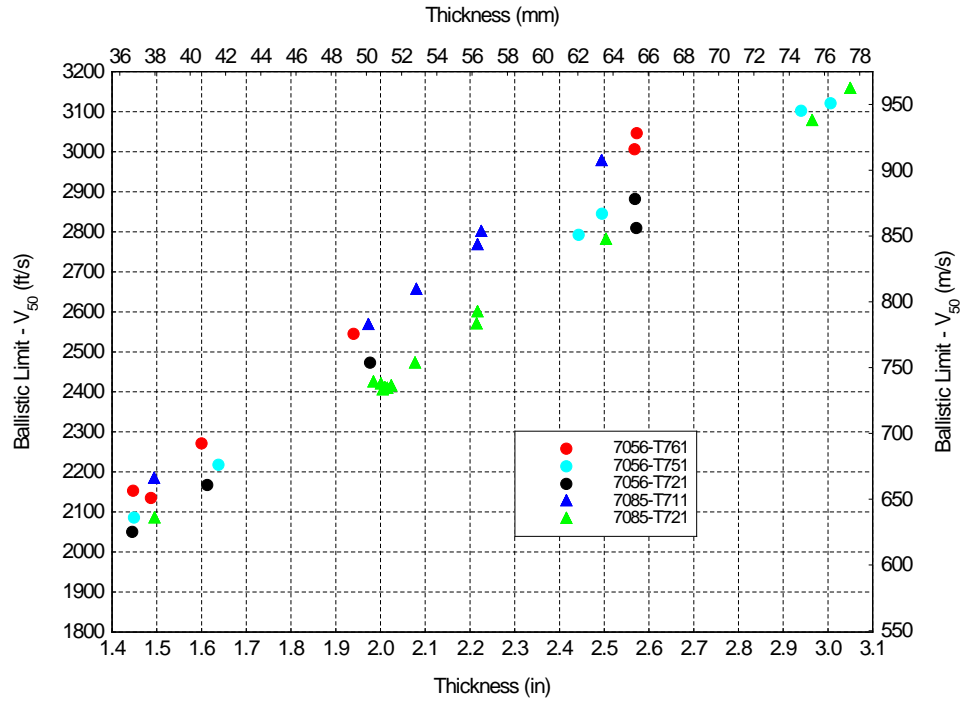


Fig. 5 Ballistic limit vs. thickness of AA7056 and AA7085 for the 0.50-cal. APM2 at 0° obliquity

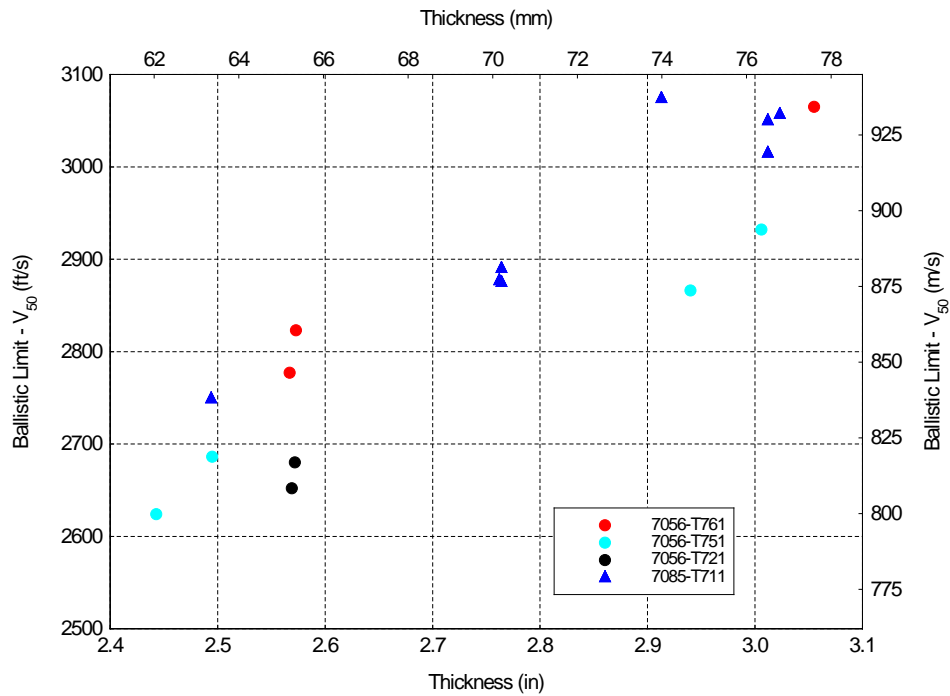


Fig. 6 Ballistic limit vs. thickness of AA7056 and AA7085 for the 14.5-mm BS41 at 0° obliquity

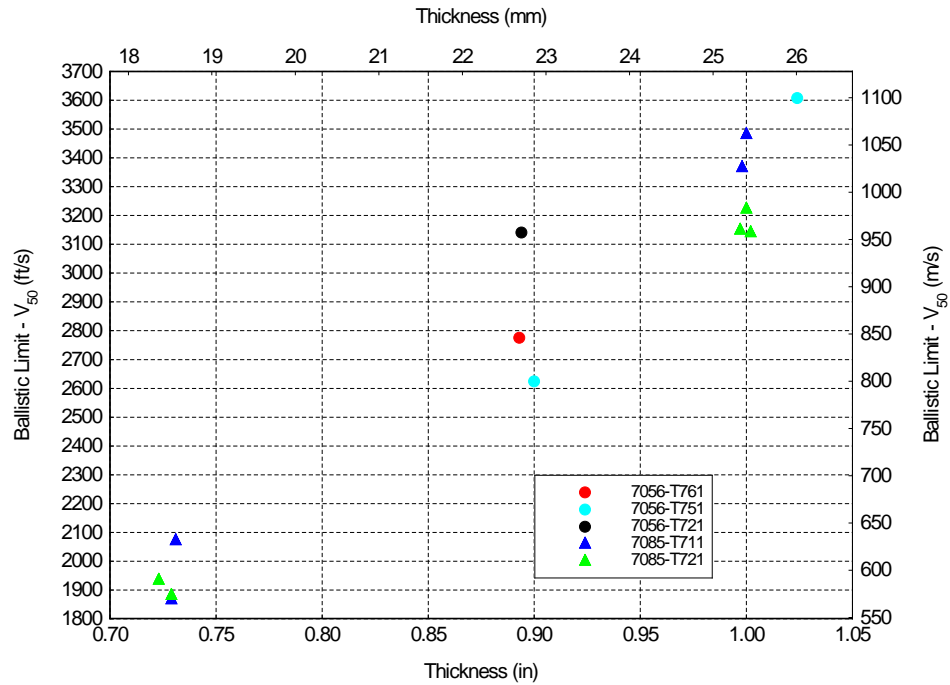


Fig. 7 Ballistic limit vs. thickness of AA7056 and AA7085 for the 0.50-cal. FSP at 0° obliquity

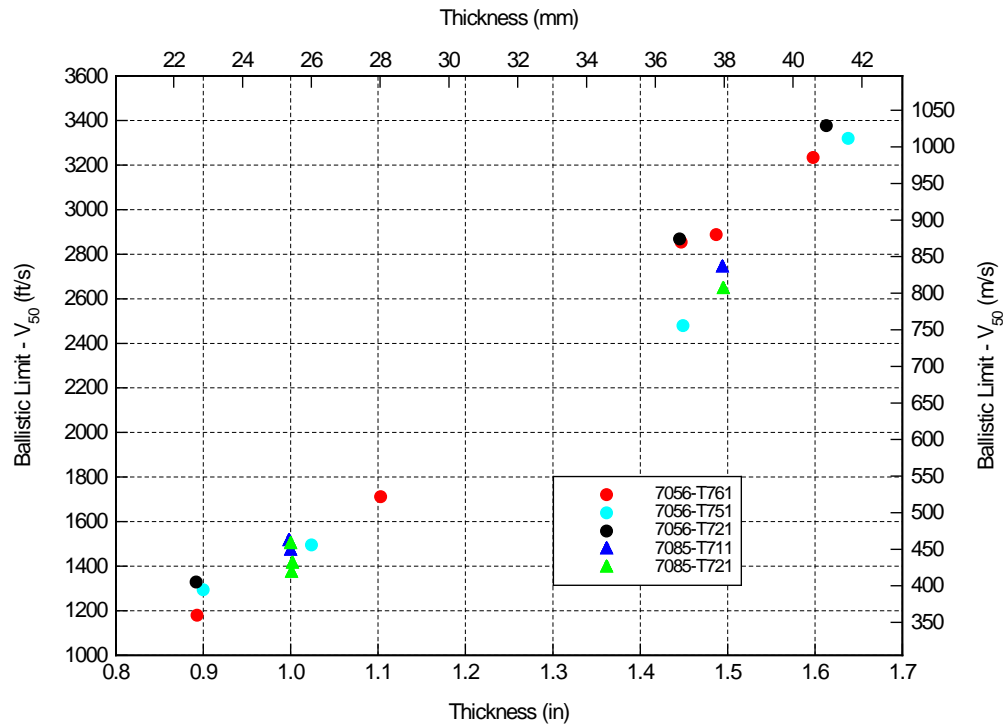


Fig. 8 Ballistic limit vs. thickness of AA7056 and AA7085 for the 20-mm FSP at 0° obliquity

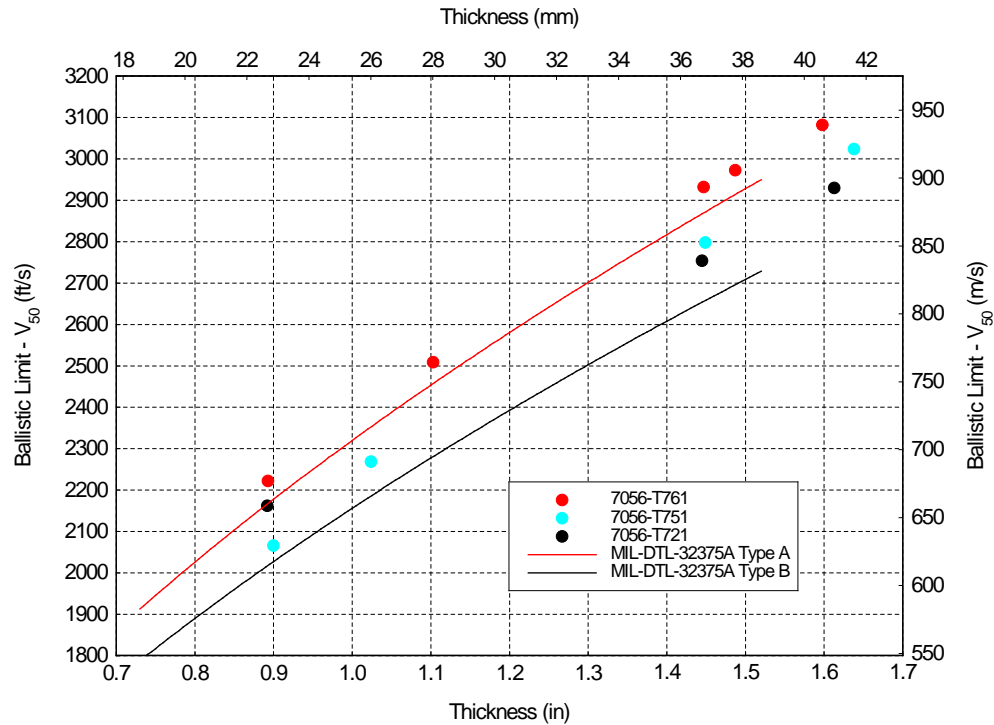


Fig. 9 Ballistic limit vs. thickness of AA7056 as compared with MIL-DTL-32375A for the 0.30-cal. APM2 at 0° obliquity

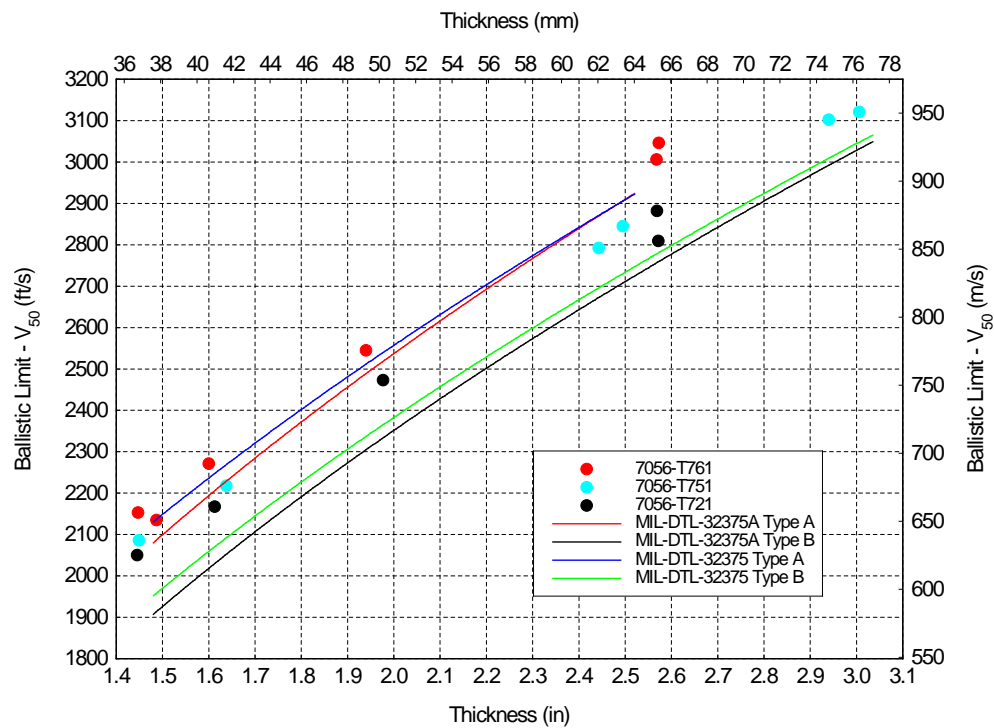


Fig. 10 Ballistic limit vs. thickness of AA7056 as compared with MIL-DTL-32375 and the revised MIL-DTL-32375A for the 0.50-cal. APM2 at 0° obliquity

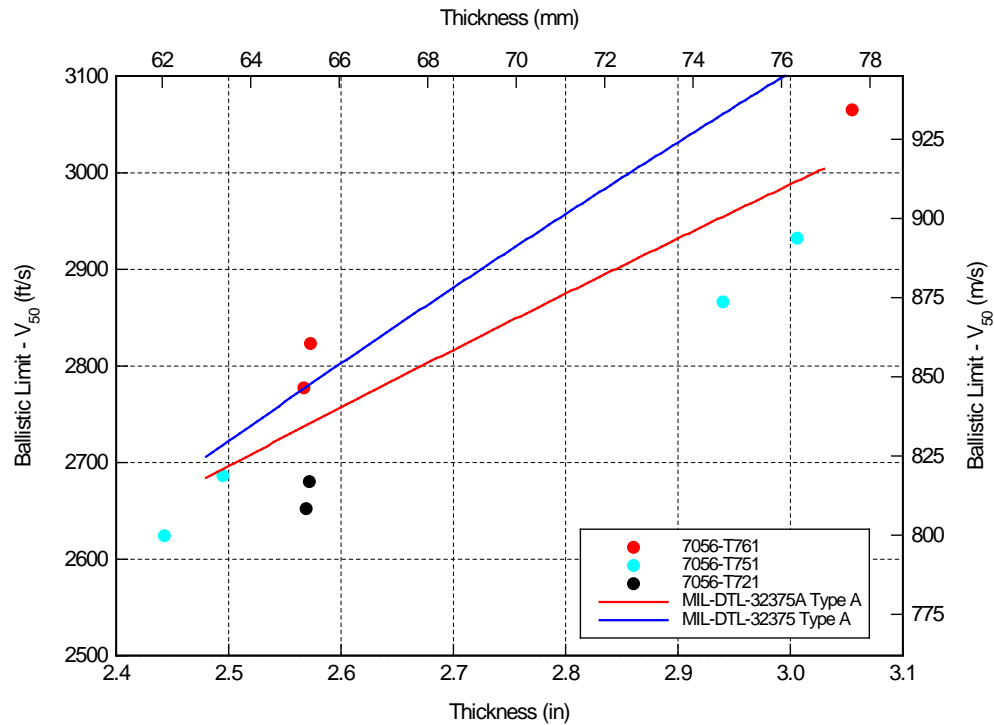


Fig. 11 Ballistic limit vs. thickness of AA7056 as compared with MIL-DTL-32375 and the revised MIL-DTL-32375A for the 14.5-mm BS41 at 0° obliquity

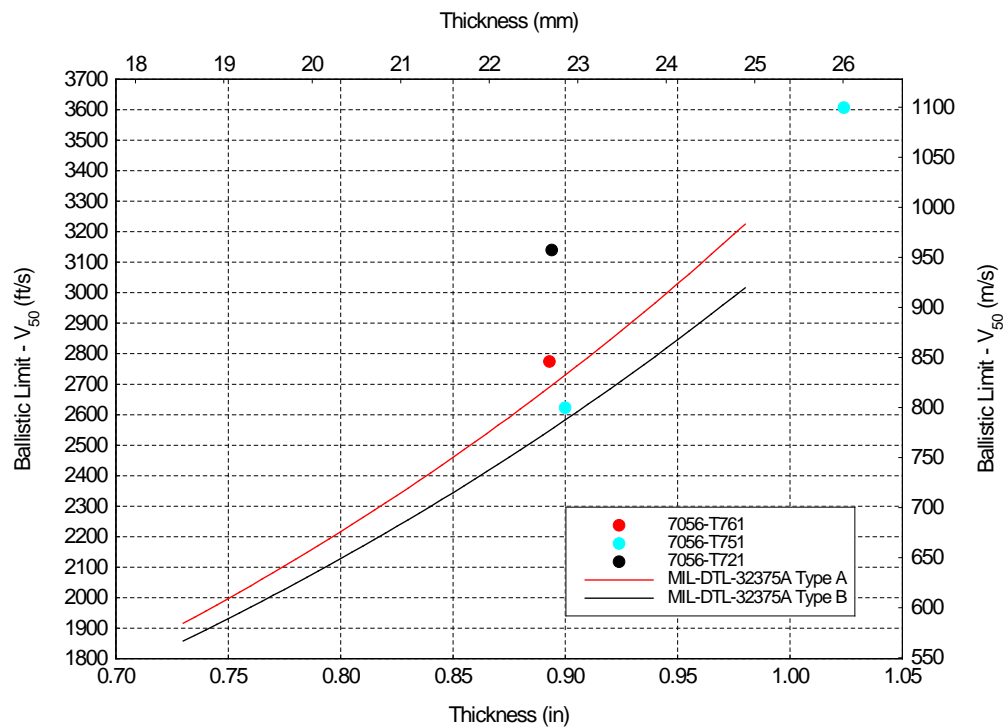


Fig. 12 Ballistic limit vs. thickness of AA7056 as compared with MIL-DTL-32375A for the 0.50-cal. FSP at 0° obliquity

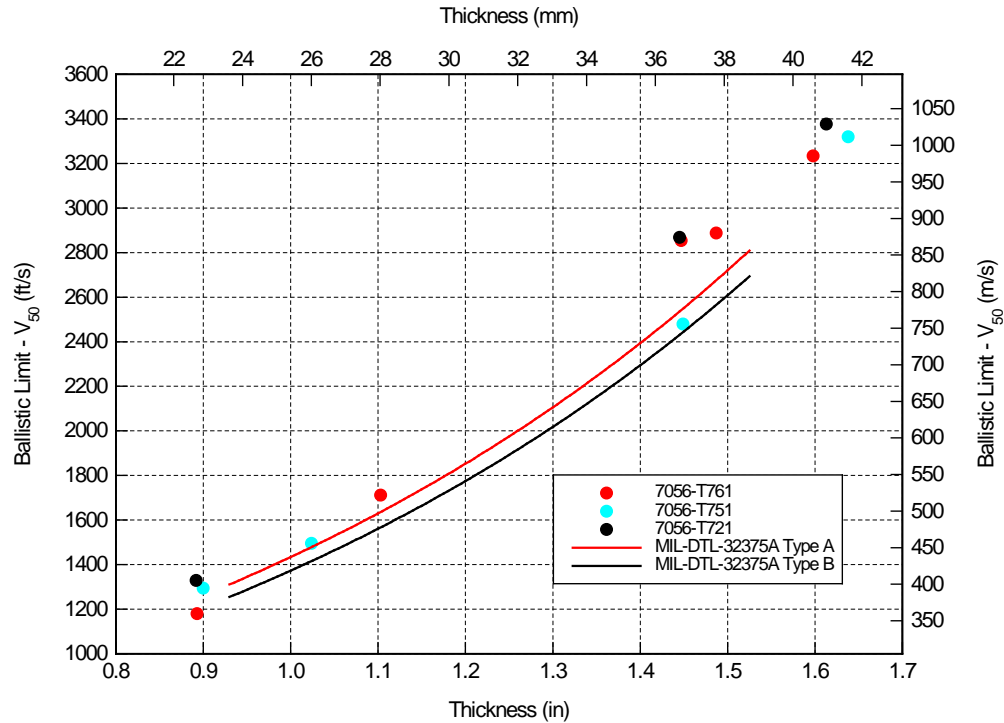


Fig. 13 Ballistic limit vs. thickness of AA7056 as compared with MIL-DTL-32375A for the 20-mm FSP at 0° obliquity

As can be observed in Figs. 4–8, the performance for AA7056 is similar to the existing AA7085 material. It would not be a stretch to consider them one data set to develop an acceptance curve. Therefore, it was decided to use one set of acceptance curves for both materials rather than include individual curves for each material in the specification. For the 0.30-cal. APM2, 0.50-cal. FSP, and 20-mm FSP (Figs. 9, 12, and 13), no changes were made to the original acceptance curves. Using the data presented in this report and additional data that had been generated on AA7085 after the original specification publication, the acceptance curves were adjusted for plate thickness requiring acceptance with the 0.50-cal. APM2 and 14.5-mm BS41 (Figs. 10 and 11). The 0.50-cal. APM2 curves were adjusted because the original curves were too close to the actual V_{50} performance of the plates in those thickness ranges and a high number of material lots were failing acceptance testing. The 14.5-mm BS41 was adjusted because the original curve was based on a limited number of experiments, and an unusually high V_{50} data point for a nominally 76.2-mm plate caused the curve to significantly shift upward. Now, with more data available, a more appropriate acceptance curve has been derived. The new acceptance velocities were calculated by fitting the combined 7056 and 7085 V_{50} data minus 2 standard deviations with Eqs. 3 and 4 for AP and FSP projectiles, respectively.^{8,9}

$$V_A = 1000\sqrt{a + bt} . \quad (3)$$

$$V_A = 1000e^{a+bt} . \quad (4)$$

In Eqs. 3 and 4, V_A is the acceptance velocity, t is the actual thickness of the plate, and both a and b are constants of regression. Table 15 lists the constants of regression for each projectile. The ballistic tables corresponding to the acceptance curves can be found in MIL-DTL-32375A (MR).

Table 15 Constants of regression for the acceptance curves for AA7056 and AA7085 used in MIL-DTL-32375A

Projectile type	7056-T761/7085-T711		7056-T721/7056-T751/7085-T721	
	a	b	a	b
0.30-cal. APM2 at 0°	-1.00510	6.38362	-0.73629	5.38098
0.50-cal. APM2 at 0°	-1.68208	4.05994	-1.74964	3.63981
14.5-mm BS41 at 0°	-1.01917	3.31534	...	...
0.50-cal. FSP at 0°	-0.87107	2.08372	-0.79585	1.93870
20-mm FSP at 0°	-0.92069	1.28106	-0.96678	1.28373

5. Conclusions

A ballistic evaluation has been performed on AA7056 in the T761, T751, and T721 tempers. This report has compared the performance of AA7056 against existing mil-spec Al-armor material, namely AA7085. AA7056 performed similar to AA7085 against the mil-spec projectiles at equal thicknesses. This report has also documented the calculations used to derive the acceptance tables included in the updated MIL-DTL-32375A (MR).

6. References

1. MIL-DTL-32375A (MR). Armor plate, aluminum, alloy, 7056 and 7085 unweldable appliqué. Aberdeen Proving Ground (MD): Army Research Laboratory (US); 2016 Jan 21.
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4. Grabarek C, Herr L. X-ray multi-flash system for measurement of projectile performance at the target. Aberdeen Proving Ground (MD): Army Ballistic Research Laboratory (US); 1966 Sep. Report No.: BRL-TN-1634.
5. Mascianica F. Ballistic technology of lightweight armor. Watertown (MA): Army Materials Research Agency (US); 1964 Sep. Report No.: AMRA MS 64-07.
6. MIL-DTL-46593B (MR). Projectile, calibers .22, .30, .50, and 20 mm fragment-simulating. Aberdeen Proving Ground (MD): Army Research Laboratory (US); 2008 Aug 11.
7. Gallardy D. Ballistic evaluation of 7085 aluminum. Aberdeen Proving Ground (MD): Army Research Laboratory (US); 2012 Mar. Report No.: ARL-TR-5952.
8. DeLuca E, Anctil A. Laminate armor for light combat vehicles. Watertown (MA): Army Materials Technology Laboratory (US); 1986 Apr. Report No.: MTL TR 86-14.
9. Van Caneghem R, Typanski D, Latham R. Appendix C: ballistic testing of aluminum armor alloys – shock testing of weldments and specification data. Aberdeen Proving Ground (MD): Army Combat Systems Test Activity (US); 1986 Apr. Report No.: MTL TR 86-14.

Appendix A. Ballistic Data: 7056-T761

This appendix appears in its original form, without editorial change.

Approved for public release; distribution is unlimited.

0.30-cal APM2

Target:		7056-T761		Date:		4/21/2015	
Plate Number:		823551		Location:		EF 106	
Thickness, in:		0.893					
Thickness, mm:		22.68					
Hardness, BHN:		179					
Obliquity:		0°					
Projectile:		0.30-cal APM2					
Velocity Measurement:		Chronograph					
V ₅₀ :		2221 ft/s	677 m/s	Number of Shots:		4	
Std Dev:		23 ft/s	7 m/s	Spread:		54 ft/s	16 m/s
ZMR:		36 ft/s	11 m/s				
Striking Velocity		Gamma	Result (PP/CP)	Used for V ₅₀ (Yes/No)	Shot Number	Comments	
(ft/s)	(m/s)	(deg)					
2127	648	--	PP	No	14298		
2403	732	--	CP	No	14299		
2249	685	--	PP	Yes	14300		
2335	712	--	CP	No	14301		
2400	731	--	CP	No	14302		
2264	690	--	CP	No	14303		
2227	679	--	CP	Yes	14304		
2195	669	--	PP	Yes	14305		
2145	654	--	PP	No	14306		
2213	674	--	CP	Yes	14307		

Target:	7056-T761			Date:	4/14/2015	
Plate Number:	823531			Location:	EF 106	
Thickness, in:	1.598					
Thickness, mm:	40.59					
Hardness, BHN:	170					
Obliquity:	0°					
Projectile:	0.30-cal APM2					
Velocity Measurement:	Chronograph					
V ₅₀ :	3081 ft/s	939 m/s	Number of Shots:		4	
Std Dev:	22 ft/s	6 m/s	Spread:		48 ft/s	14 m/s
ZMR:	N/A	N/A				
Striking Velocity		Gamma	Result (PP/CP)	Used for V ₅₀ (Yes/No)	Shot Number	Comments
(ft/s)	(m/s)	(deg)				
2920	890	--	PP	No	14285	
3112	948	--	CP	Yes	14286	
3020	920	--	PP	No	14287	
3064	934	--	PP	Yes	14288	
3078	938	--	CP	Yes	14289	
3069	935	--	PP	Yes	14290	

Target:	7056-T761			Date:	1/22/2015	
Plate Number:	823551			Location:	EF 106	
Thickness, in:	1.103					
Thickness, mm:	28.02					
Hardness, BHN:	179					
Obliquity:	0°					
Projectile:	0.30-cal APM2					
Velocity Measurement:	Chronograph					
V ₅₀ :	2508 ft/s	764 m/s	Number of Shots:		4	
Std Dev:	22 ft/s	7 m/s	Spread:		50 ft/s	15 m/s
ZMR:	N/A	N/A				
Striking Velocity		Gamma	Result (PP/CP)	Used for V ₅₀ (Yes/No)	Shot Number	Comments
(ft/s)	(m/s)	(deg)				
2547	776	--	CP	No	14146	
2416	736	--	PP	No	14147	
2507	764	--	PP	Yes	14148	
2552	778	--	CP	No	14149	
2447	746	--	PP	No	14150	
2538	774	--	CP	No	14151	
2544	775	--	CP	No	14152	
2477	755	--	PP	Yes	14153	
2527	770	--	CP	Yes	14154	
2520	768	--	CP	Yes	14155	

Target:	7056-T761			Date:	1/20/2015	
Plate Number:	823531			Location:	EF 106	
Thickness, in:	1.447					
Thickness, mm:	36.75					
Hardness, BHN:	174					
Obliquity:	0°					
Projectile:	0.30-cal APM2					
Velocity Measurement:	Chronograph					
V ₅₀ :	2931 ft/s	893 m/s	Number of Shots:		4	
Std Dev:	26 ft/s	8 m/s	Spread:		53 ft/s	16 m/s
ZMR:	N/A	N/A				
Striking Velocity		Gamma	Result (PP/CP)	Used for V ₅₀ (Yes/No)	Shot Number	Comments
(ft/s)	(m/s)	(deg)				
2953	900	--	CP	Yes	14135	
2756	840	--	PP	No	14136	
2852	869	--	PP	No	14137	
2900	884	--	PP	Yes	14138	
2919	890	--	PP	Yes	14139	
2951	899	--	CP	Yes	14140	

Target:	7056-T761			Date:	9/2/2015	
Plate Number:	900305			Location:	EF 108	
Thickness, in:	1.487					
Thickness, mm:	37.77					
Hardness, BHN:	179					
Obliquity:	0°					
Projectile:	0.30-cal APM2					
Velocity Measurement:	Chronograph					
V ₅₀ :	2972 ft/s	906 m/s	Number of Shots:		4	
Std Dev:	18 ft/s	5 m/s	Spread:		42 ft/s	12 m/s
ZMR:	N/A	N/A				
Striking Velocity		Gamma	Result (PP/CP)	Used for V ₅₀ (Yes/No)	Shot Number	Comments
(ft/s)	(m/s)	(deg)				
2933	894	--	PP	No	12958	
2997	913	--	CP	Yes	12959	
2955	901	--	PP	Yes	12960	
2972	906	--	CP	Yes	12961	
2963	903	--	PP	Yes	12962	

0.50-cal APM2

Target:	7056-T761			Date:	3/26/2015	
Plate Number:	823531			Location:	EF 108	
Thickness, in:	1.447					
Thickness, mm:	36.75					
Hardness, BHN:	174					
Obliquity:	0°					
Projectile:	0.50 cal APM2					
Velocity Measurement:	X-Ray					
V ₅₀ :	2153 ft/s	656 m/s	Number of Shots:		4	
Std Dev:	25 ft/s	8 m/s	Spread:		56 ft/s	17 m/s
ZMR:	N/A	N/A				
Striking Velocity		Gamma	Result	Used for V ₅₀	Shot	Comments
(ft/s)	(m/s)	(deg)	(PP/CP)	(Yes/No)	Number	
2284	696	0.22	CP	No	12608	
2206	672	0.88	CP	No	12609	
2080	634	0.40	PP	No	12610	
2182	665	0.54	CP	Yes	12611	
2126	648	0.14	PP	Yes	12612	
2139	652	0.61	PP	Yes	12613	
2165	660	0.52	CP	Yes	12614	

Target:	7056-T761			Date:	2/13/2015	
Plate Number:	823561			Location:	EF 108	
Thickness, in:	2.573					
Thickness, mm:	65.35					
Hardness, BHN:	179					
Obliquity:	0°					
Projectile:	0.50 cal APM2					
Velocity Measurement:	X-Ray					
V ₅₀ :	3046 ft/s	928 m/s	Number of Shots:		4	
Std Dev:	20 ft/s	6 m/s	Spread:		48 ft/s	14 m/s
ZMR:	N/A	N/A				
Striking Velocity		Gamma	Result (PP/CP)	Used for V ₅₀ (Yes/No)	Shot Number	Comments
(ft/s)	(m/s)	(deg)				
3164	964	1.14	CP	No	12541	
3024	922	0.82	PP	Yes	12542	
3112	948	0.47	CP	No	12543	
3110	948	1.21	CP	No	12544	
3072	936	0.62	CP	Yes	12545	
3046	928	0.47	PP	Yes	12546	
3043	927	0.26	CP	Yes	12547	

Target:	7056-T761			Date:	2/11/2015	
Plate Number:	823541			Location:	EF 108	
Thickness, in:	2.568					
Thickness, mm:	65.23					
Hardness, BHN:	174					
Obliquity:	0°					
Projectile:	0.50 cal APM2					
Velocity Measurement:	X-Ray					
V ₅₀ :	3006 ft/s	916 m/s	Number of Shots:		4	
Std Dev:	22 ft/s	7 m/s	Spread:		44 ft/s	13 m/s
ZMR:	N/A	N/A				
Striking Velocity		Gamma	Result (PP/CP)	Used for V ₅₀ (Yes/No)	Shot Number	Comments
(ft/s)	(m/s)	(deg)				
3183	970	0.76	CP	No	12536	
2982	909	1.03	PP	Yes	12537	
2993	912	1.03	PP	Yes	12538	
3026	922	0.67	CP	Yes	12539	
3024	922	1.04	CP	Yes	12540	

Target:	7056-T761			Date:	2/10/2015	
Plate Number:	823531			Location:	EF 108	
Thickness, in:	1.600					
Thickness, mm:	40.64					
Hardness, BHN:	170					
Obliquity:	0°					
Projectile:	0.50 cal APM2					
Velocity Measurement:	X-Ray					
V ₅₀ :	2271 ft/s	692 m/s	Number of Shots:		4	
Std Dev:	20 ft/s	6 m/s	Spread:		46 ft/s	14 m/s
ZMR:	N/A	N/A				
Striking Velocity		Gamma	Result (PP/CP)	Used for V ₅₀ (Yes/No)	Shot Number	Comments
(ft/s)	(m/s)	(deg)				
2535	773	0.89	CP	No	12528	
2336	712	0.42	CP	No	12529	
2191	668	0.45	PP	No	12530	
2259	689	0.23	PP	Yes	12531	
2329	710	0.28	CP	No	12532	
2298	700	1.01	CP	Yes	12533	
2252	686	0.18	PP	Yes	12534	
2273	693	0.91	CP	Yes	12535	

Target:	7056-T761			Date:	8/26/2015	
Plate Number:	900305			Location:	EF 108	
Thickness, in:	1.487					
Thickness, mm:	37.77					
Hardness, BHN:	179					
Obliquity:	0°					
Projectile:	0.50 cal APM2					
Velocity Measurement:	X-Ray					
V ₅₀ :	2135 ft/s	651 m/s	Number of Shots:		4	
Std Dev:	15 ft/s	5 m/s	Spread:		37 ft/s	11 m/s
ZMR:	4 ft/s	1 m/s				
Striking Velocity		Gamma	Result (PP/CP)	Used for V ₅₀ (Yes/No)	Shot Number	Comments
(ft/s)	(m/s)	(deg)				
2213	674	0.50	CP	No	12933	
2138	652	0.10	PP	Yes	12934	
2152	656	0.46	CP	Yes	12935	
2134	650	0.58	CP	Yes	12936	Large Spall Started
2115	645	0.33	PP	Yes	12937	

Target:	7056-T761			Date:	8/27/2015	
Plate Number:	900294			Location:	EF 108	
Thickness, in:	1.940					
Thickness, mm:	49.28					
Hardness, BHN:	170					
Obliquity:	0°					
Projectile:	0.50 cal APM2					
Velocity Measurement:	X-Ray					
V ₅₀ :	2545 ft/s	776 m/s	Number of Shots:		4	
Std Dev:	17 ft/s	5 m/s	Spread:		41 ft/s	12 m/s
ZMR:	N/A	N/A				
Striking Velocity		Gamma	Result (PP/CP)	Used for V ₅₀ (Yes/No)	Shot Number	Comments
(ft/s)	(m/s)	(deg)				
2671	814	0.65	CP	No	12943	
2621	799	0.54	CP	No	12944	
2620	799	0.45	CP	No	12945	
2457	749	0.20	PP	No	12946	
2526	770	0.36	PP	Yes	12947	
2567	782	0.73	CP	Yes	12948	
2539	774	0.68	PP	Yes	12949	
2546	776	0.30	CP	Yes	12950	

14.5-mm BS41

Target:	7056-T761			Date:	2/26/2015	
Plate Number:	823561			Location:	EF 106	
Thickness, in:	2.573					
Thickness, mm:	65.35					
Hardness, BHN:	179					
Obliquity:	0°					
Projectile:	14.5-mm BS41					
Velocity Measurement:	X-Ray					
V ₅₀ :	2823 ft/s	860 m/s	Number of Shots:		4	
Std Dev:	17 ft/s	5 m/s	Spread:		42 ft/s	13 m/s
ZMR:	5 ft/s	2 m/s				
Striking Velocity		Gamma	Result (PP/CP)	Used for V ₅₀ (Yes/No)	Shot Number	Comments
(ft/s)	(m/s)	(deg)				
2825	861	1.02	PP	Yes	14204	
2962	903	1.54	CP	No	14205	
2945	898	1.19	CP	No	14206	
2913	888	0.96	CP	No	14207	
2923	891	--	CP	No	14208	Switched to Chrono
2887	880	--	CP	No	14209	
2844	867	--	CP	Yes	14210	
2820	859	--	CP	Yes	14211	
2802	854	--	PP	Yes	14212	
2790	850	--	PP	No	14213	

Target:	7056-T761			Date:	3/4/2015	
Plate Number:	823541			Location:	EF 106	
Thickness, in:	2.567					
Thickness, mm:	65.20					
Hardness, BHN:	174					
Obliquity:	0°					
Projectile:	14.5-mm BS41					
Velocity Measurement:	Chrono					
V ₅₀ :	2777 ft/s	847 m/s	Number of Shots:		4	
Std Dev:	19 ft/s	6 m/s	Spread:		41 ft/s	13 m/s
ZMR:	N/A	N/A				
Striking Velocity		Gamma	Result (PP/CP)	Used for V ₅₀ (Yes/No)	Shot Number	Comments
(ft/s)	(m/s)	(deg)				
2804	855	--	CP	Yes	14214	
2763	842	--	PP	Yes	14215	
2771	845	--	CP	Yes	14216	
2768	844	--	PP	Yes	14217	

Target:	7056-T761			Date:	8/31/2015	
Plate Number:	900293			Location:	EF 108	
Thickness, in:	3.055					
Thickness, mm:	77.60					
Hardness, BHN:	183					
Obliquity:	0°					
Projectile:	14.5-mm BS41					
Velocity Measurement:	X-ray					
V ₅₀ :	3065 ft/s	934 m/s	Number of Shots:		4	
Std Dev:	26 ft/s	8 m/s	Spread:		59 ft/s	18 m/s
ZMR:	N/A	N/A				
Striking Velocity		Gamma	Result (PP/CP)	Used for V ₅₀ (Yes/No)	Shot Number	Comments
(ft/s)	(m/s)	(deg)				
3210	978	0.10	CP	No	12951	
3175	968	0.37	CP	No	12952	
3099	945	0.59	CP	Yes	12953	
3030	923	0.30	PP	No	12954	
3040	927	0.36	PP	Yes	12955	
3068	935	0.58	CP	Yes	12956	
3051	930	0.20	PP	Yes	12957	

0.50-cal FSP

Target:	7056-T761			Date:	1/29/2015	
Plate Number:	823551			Location:	EF 106	
Thickness, in:	0.893					
Thickness, mm:	22.68					
Hardness, BHN:	179					
Obliquity:	0°					
Projectile:	0.50-cal FSP					
Velocity Measurement:	Chronograph					
V ₅₀ :	2774 ft/s	846 m/s	Number of Shots:		4	
Std Dev:	19 ft/s	5 m/s	Spread:		45 ft/s	13 m/s
ZMR:	3 ft/s	1 m/s				
Striking Velocity		Gamma	Result (PP/CP)	Used for V ₅₀ (Yes/No)	Shot Number	Comments
(ft/s)	(m/s)	(deg)				
2972	906	--	CP	No	14156	
2719	829	--	PP	No	14157	
2836	864	--	CP	No	14158	
2776	846	--	CP	Yes	14159	
2748	838	--	PP	Yes	14160	
2793	851	--	CP	Yes	14161	
2779	847	--	PP	Yes	14162	

20-mm FSP

Target:	7056-T761			Date:	4/1/2015	
Plate Number:	823551			Location:	EF 106	
Thickness, in:	0.893					
Thickness, mm:	22.68					
Hardness, BHN:	179					
Obliquity:	0°					
Projectile:	20-mm FSP					
Velocity Measurement:	X-ray					
V ₅₀ :	1180 ft/s	360 m/s		Number of Shots:	10	
Std Dev:	45 ft/s	14 m/s		Spread:	126 ft/s	38 m/s
ZMR:	110 ft/s	33 m/s				
Striking Velocity		Gamma	Result (PP/CP)	Used for V ₅₀ (Yes/No)	Shot Number	Comments
(ft/s)	(m/s)	(deg)				
1364	416	0.23	CP	No	14260	
1261	384	1.95	PP	Yes	14261	
1305	398	1.01	CP	No	14262	
1236	377	1.44	CP	Yes	14263	
1220	372	0.55	CP	Yes	14264	
1146	349	0.10	PP	Yes	14265	
1197	365	0.62	CP	Yes	14266	
1168	356	0.75	CP	Yes	14267	
1135	346	1.12	PP	Yes	14268	
1151	351	0.68	CP	Yes	14269	
1138	347	0.72	PP	Yes	14270	
1149	350	0.83	PP	Yes	14271	

Target:	7056-T761			Date:	4/7/2015	
Plate Number:	823531			Location:	EF 106	
Thickness, in:	1.447					
Thickness, mm:	36.75					
Hardness, BHN:	174					
Obliquity:	0°					
Projectile:	20-mm FSP					
Velocity Measurement:	X-ray					
V ₅₀ :	2854 ft/s	870 m/s	Number of Shots:		4	
Std Dev:	23 ft/s	7 m/s	Spread:		49 ft/s	15 m/s
ZMR:	N/A	N/A				
Striking Velocity		Gamma	Result (PP/CP)	Used for V ₅₀ (Yes/No)	Shot Number	Comments
(ft/s)	(m/s)	(deg)				
2847	868	0.78	PP	Yes	14272	
2873	876	0.24	CP	Yes	14273	
2871	875	0.16	CP	Yes	14274	
2824	861	1.31	PP	Yes	14275	

Target:	7056-T761			Date:	4/8/2015	
Plate Number:	823531			Location:	EF 106	
Thickness, in:	1.598					
Thickness, mm:	40.59					
Hardness, BHN:	170					
Obliquity:	0°					
Projectile:	20-mm FSP					
Velocity Measurement:	X-ray					
V ₅₀ :	3234 ft/s	986 m/s	Number of Shots:		4	
Std Dev:	14 ft/s	4 m/s	Spread:		32 ft/s	10 m/s
ZMR:	12 ft/s	4 m/s				
Striking Velocity		Gamma	Result (PP/CP)	Used for V ₅₀ (Yes/No)	Shot Number	Comments
(ft/s)	(m/s)	(deg)				
3543	1080	0.65	CP	No	14276	
3374	1028	1.97	CP	No	14277	
3242	988	0.63	PP	Yes	14278	
3299	1005	1.32	CP	No	14279	
3230	984	0.43	CP	Yes	14280	
3247	990	1.30	CP	Yes	14281	
3215	980	1.34	PP	Yes	14282	

Target:	7056-T761			Date:	2/10/2015	
Plate Number:	823551			Location:	EF 106	
Thickness, in:	1.103					
Thickness, mm:	28.02					
Hardness, BHN:	179					
Obliquity:	0°					
Projectile:	20-mm FSP					
Velocity Measurement:	X-ray					
V ₅₀ :	1711 ft/s	522 m/s	Number of Shots:		4	
Std Dev:	15 ft/s	4 m/s	Spread:		35 ft/s	10 m/s
ZMR:	35 ft/s	10 m/s				
Striking Velocity		Gamma	Result (PP/CP)	Used for V ₅₀ (Yes/No)	Shot Number	Comments
(ft/s)	(m/s)	(deg)				
2707	825	0.05	CP	No	14181	
2541	774	1.10	CP	No	14182	
2271	692	1.30	CP	No	14183	
1888	575	1.22	CP	No	14184	
1716	523	1.01	PP	Yes	14185	
1724	525	1.63	PP	Yes	14186	
1804	550	0.49	CP	No	14187	
1716	523	0.26	CP	Yes	14188	
1692	516	1.01	PP	No	14189	
1689	515	0.64	CP	Yes	14190	

Target:	7056-T761			Date:	9/8/2015	
Plate Number:	900305			Location:	EF 108	
Thickness, in:	1.487					
Thickness, mm:	37.77					
Hardness, BHN:	179					
Obliquity:	0°					
Projectile:	20-mm FSP					
Velocity Measurement:	X-ray					
V ₅₀ :	2887 ft/s	880 m/s	Number of Shots:		4	
Std Dev:	23 ft/s	7 m/s	Spread:		54 ft/s	16 m/s
ZMR:	5 ft/s	2 m/s				
Striking Velocity		Gamma	Result (PP/CP)	Used for V ₅₀ (Yes/No)	Shot Number	Comments
(ft/s)	(m/s)	(deg)				
2891	881	0.16	CP	Yes	12963	
2854	870	0.15	PP	Yes	12964	
2896	883	0.41	PP	Yes	12965	
2908	886	0.31	CP	Yes	12966	

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Appendix B. Ballistic Data: 7056-T751 and 7056-T721

This appendix appears in its original form, without editorial change.
Approved for public release; distribution is unlimited.

0.30-cal APM2

Target:		7056-T751		Date:		8/26/2014	
Plate Number:		647911		Location:		EF 106	
Thickness, in:		1.024					
Thickness, mm:		26.01					
Hardness, BHN:		156					
Obliquity:		0°					
Projectile:		0.30-cal APM2					
Velocity Measurement:		Chronograph					
V ₅₀ :		2268 ft/s	691 m/s	Number of Shots:		4	
Std Dev:		19 ft/s	6 m/s	Spread:		44 ft/s	13 m/s
ZMR:		6 ft/s	2 m/s				
Striking Velocity		Gamma	Result (PP/CP)	Used for V ₅₀ (Yes/No)	Shot Number	Comments	
(ft/s)	(m/s)	(deg)					
2251	686	--	PP	Yes	13843		
2381	726	--	CP	No	13844		
2265	690	--	PP	Yes	13845		
2385	727	--	CP	No	13846		
2335	712	--	CP	No	13847		
2295	699	--	CP	Yes	13848		
2325	709	--	CP	No	13849		
2259	689	--	CP	Yes	13850		

Target:	7056-T751			Date:	8/25/2014	
Plate Number:	647911			Location:	EF 106	
Thickness, in:	0.900					
Thickness, mm:	22.86					
Hardness, BHN:	159					
Obliquity:	0°					
Projectile:	0.30-cal APM2					
Velocity Measurement:	Chronograph					
V ₅₀ :	2065 ft/s	629 m/s	Number of Shots:		4	
Std Dev:	21 ft/s	7 m/s	Spread:		48 ft/s	15 m/s
ZMR:	6 ft/s	2 m/s				
Striking Velocity		Gamma	Result (PP/CP)	Used for V ₅₀ (Yes/No)	Shot Number	Comments
(ft/s)	(m/s)	(deg)				
2141	653	--	CP	No	13832	
2055	626	--	CP	Yes	13833	
1860	567	--	PP	No	13834	
2009	612	--	PP	No	13835	
2061	628	--	PP	Yes	13836	
1971	601	--	PP	No	13837	
2008	612	--	PP	No	13838	
2027	618	--	PP	No	13839	
2131	649	--	CP	No	13840	
2095	639	--	CP	Yes	13841	
2047	624	--	PP	Yes	13842	

Target:	7056-T751			Date:	12/11/2014	
Plate Number:	647921			Location:	EF 106	
Thickness, in:	1.638					
Thickness, mm:	41.61					
Hardness, BHN:	156					
Obliquity:	0°					
Projectile:	0.30-cal APM2					
Velocity Measurement:	Chronograph					
V ₅₀ :	3023 ft/s	922 m/s	Number of Shots:		4	
Std Dev:	25 ft/s	8 m/s	Spread:		55 ft/s	17 m/s
ZMR:	N/A	N/A				
Striking Velocity		Gamma	Result (PP/CP)	Used for V ₅₀ (Yes/No)	Shot Number	Comments
(ft/s)	(m/s)	(deg)				
2729	832	--	PP	No	14090	
2998	914	--	PP	No	14091	
3146	959	--	CP	No	14092	
2885	879	--	PP	No	14093	
3005	916	--	PP	Yes	14094	
3060	933	--	CP	Yes	14095	
3016	919	--	CP	Yes	14096	
3012	918	--	PP	Yes	14097	

Target:	7056-T751			Date:	8/28/2014	
Plate Number:	647921			Location:	EF 106	
Thickness, in:	1.449					
Thickness, mm:	36.80					
Hardness, BHN:	166					
Obliquity:	0°					
Projectile:	0.30-cal APM2					
Velocity Measurement:	Chronograph					
V ₅₀ :	2797 ft/s	853 m/s	Number of Shots:		4	
Std Dev:	15 ft/s	5 m/s	Spread:		35 ft/s	11 m/s
ZMR:	N/A	N/A				
Striking Velocity		Gamma	Result (PP/CP)	Used for V ₅₀ (Yes/No)	Shot Number	Comments
(ft/s)	(m/s)	(deg)				
2688	819	--	PP	No	13851	
2800	853	--	PP	Yes	13852	
2902	884	--	CP	No	13853	
2841	866	--	CP	No	13854	
2853	870	--	CP	No	13855	
2811	857	--	CP	Yes	13856	
2801	854	--	CP	Yes	13857	
2776	846	--	PP	Yes	13858	

Target:	7056-T721			Date:	4/23/2015	
Plate Number:	649471			Location:	EF 106	
Thickness, in:	0.892					
Thickness, mm:	22.66					
Hardness, BHN:	153					
Obliquity:	0°					
Projectile:	0.30-cal APM2					
Velocity Measurement:	Chronograph					
V ₅₀ :	2161 ft/s	659 m/s	Number of Shots:		4	
Std Dev:	18 ft/s	5 m/s	Spread:		42 ft/s	13 m/s
ZMR:	N/A	N/A				
Striking Velocity		Gamma	Result (PP/CP)	Used for V ₅₀ (Yes/No)	Shot Number	Comments
(ft/s)	(m/s)	(deg)				
2048	624	--	PP	No	14308	
2321	707	--	CP	No	14309	
2232	680	--	CP	No	14310	
2098	639	--	PP	No	14311	
2238	682	--	CP	No	14312	
2157	657	--	PP	Yes	14313	
2234	681	--	CP	No	14314	
2166	660	--	CP	Yes	14315	
2182	665	--	CP	Yes	14316	
2140	652	--	PP	Yes	14317	

Target:	7056-T721			Date:	4/16/2015	
Plate Number:	649461			Location:	EF 106	
Thickness, in:	1.613					
Thickness, mm:	40.97					
Hardness, BHN:	143					
Obliquity:	0°					
Projectile:	0.30-cal APM2					
Velocity Measurement:	Chronograph					
V ₅₀ :	2929 ft/s	893 m/s	Number of Shots:		4	
Std Dev:	19 ft/s	6 m/s	Spread:		39 ft/s	12 m/s
ZMR:	N/A	N/A				
Striking Velocity		Gamma	Result (PP/CP)	Used for V ₅₀ (Yes/No)	Shot Number	Comments
(ft/s)	(m/s)	(deg)				
3066	934	--	CP	No	14291	
2994	913	--	CP	No	14292	
2810	856	--	PP	No	14293	
2917	889	--	PP	Yes	14294	
2956	901	--	CP	Yes	14295	
2925	891	--	CP	Yes	14296	
2917	889	--	PP	Yes	14297	

Target:	7056-T721			Date:	1/21/2015	
Plate Number:	649461			Location:	EF 106	
Thickness, in:	1.445					
Thickness, mm:	36.70					
Hardness, BHN:	143					
Obliquity:	0°					
Projectile:	0.30-cal APM2					
Velocity Measurement:	Chronograph					
V ₅₀ :	2753 ft/s	839 m/s	Number of Shots:		4	
Std Dev:	24 ft/s	7 m/s	Spread:		49 ft/s	15 m/s
ZMR:	N/A	N/A				
Striking Velocity		Gamma	Result (PP/CP)	Used for V ₅₀ (Yes/No)	Shot Number	Comments
(ft/s)	(m/s)	(deg)				
2731	832	--	PP	Yes	14141	
2804	855	--	CP	No	14142	
2780	847	--	CP	Yes	14143	
2767	843	--	CP	Yes	14144	
2735	834	--	PP	Yes	14145	

0.50-cal APM2

Target:		7056-T751		Date:		9/8/2014	
Plate Number:		933181		Location:		EF 108	
Thickness, in:		2.443					
Thickness, mm:		62.05					
Hardness, BHN:		156					
Obliquity:		0°					
Projectile:		0.50 cal APM2					
Velocity Measurement:		X-Ray					
V ₅₀ :		2792 ft/s	851 m/s	Number of Shots:		4	
Std Dev:		22 ft/s	7 m/s	Spread:		47 ft/s	15 m/s
ZMR:		N/A	N/A				
Striking Velocity		Gamma	Result (PP/CP)	Used for V ₅₀ (Yes/No)	Shot Number	Comments	
(ft/s)	(m/s)	(deg)					
2847	868	0.89	CP	No	12233		
2770	844	0.59	PP	Yes	12234		
2817	859	0.74	CP	Yes	12235		
2802	854	0.05	CP	Yes	12236		
2743	836	0.70	PP	No	12237		
2778	847	1.28	PP	Yes	12238		

Target:	7056-T751			Date:	9/9/2014	
Plate Number:	933181			Location:	EF 108	
Thickness, in:	2.495					
Thickness, mm:	63.37					
Hardness, BHN:	156					
Obliquity:	0°					
Projectile:	0.50 cal APM2					
Velocity Measurement:	X-Ray					
V ₅₀ :	2845 ft/s	867 m/s	Number of Shots:		6	
Std Dev:	29 ft/s	9 m/s	Spread:		71 ft/s	22 m/s
ZMR:	7 ft/s	3 m/s				
Striking Velocity		Gamma	Result (PP/CP)	Used for V ₅₀ (Yes/No)	Shot Number	Comments
(ft/s)	(m/s)	(deg)				
2886	880	0.64	CP	Yes	12239	
2843	867	0.70	PP	Yes	12240	
2875	876	0.74	CP	Yes	12241	
2817	859	0.96	PP	Yes	12242	
2815	858	0.81	PP	Yes	12243	
2836	864	0.69	CP	Yes	12244	

Target:	7056-T751			Date:	9/3/2014	
Plate Number:	647921			Location:	EF 108	
Thickness, in:	1.638					
Thickness, mm:	41.61					
Hardness, BHN:	156					
Obliquity:	0°					
Projectile:	0.50 cal APM2					
Velocity Measurement:	X-Ray					
V ₅₀ :	2218 ft/s	676 m/s	Number of Shots:		6	
Std Dev:	30 ft/s	9 m/s	Spread:		83 ft/s	25 m/s
ZMR:	N/A	N/A				
Striking Velocity		Gamma	Result (PP/CP)	Used for V ₅₀ (Yes/No)	Shot Number	Comments
(ft/s)	(m/s)	(deg)				
2219	676	0.40	CP	Yes	12226	
2165	660	0.60	PP	No	12227	
2203	671	0.86	PP	Yes	12228	
2262	689	0.44	CP	Yes	12229	
2242	683	0.67	CP	Yes	12230	
2179	664	0.36	PP	Yes	12231	
2201	671	0.62	PP	Yes	12232	

Target:	7056-T751			Date:	11/25/2014	
Plate Number:	647921			Location:	EF 108	
Thickness, in:	1.449					
Thickness, mm:	36.80					
Hardness, BHN:	166					
Obliquity:	0°					
Projectile:	0.50 cal APM2					
Velocity Measurement:	X-Ray					
V ₅₀ :	2086 ft/s	636 m/s	Number of Shots:		4	
Std Dev:	26 ft/s	8 m/s	Spread:		57 ft/s	18 m/s
ZMR:	N/A	N/A				
Striking Velocity		Gamma	Result (PP/CP)	Used for V ₅₀ (Yes/No)	Shot Number	Comments
(ft/s)	(m/s)	(deg)				
2070	631	0.62	PP	Yes	12427	
2118	646	0.58	CP	Yes	12428	
2093	638	0.21	CP	Yes	12429	
2061	628	0.64	PP	Yes	12430	

Target:	7056-T721			Date:	3/31/2015	
Plate Number:	649461			Location:	EF 108	
Thickness, in:	1.445					
Thickness, mm:	36.70					
Hardness, BHN:	143					
Obliquity:	0°					
Projectile:	0.50 cal APM2					
Velocity Measurement:	X-Ray					
V ₅₀ :	2050 ft/s	625 m/s	Number of Shots:		4	
Std Dev:	24 ft/s	8 m/s	Spread:		55 ft/s	17 m/s
ZMR:	N/A	N/A				
Striking Velocity		Gamma	Result (PP/CP)	Used for V ₅₀ (Yes/No)	Shot Number	Comments
(ft/s)	(m/s)	(deg)				
2142	653	0.70	CP	No	12615	
2052	625	1.14	PP	Yes	12616	
2107	642	1.01	CP	No	12617	
2096	639	0.89	CP	No	12618	
2070	631	0.49	CP	Yes	12619	
1934	589	1.16	PP	No	12620	
1978	603	0.91	PP	No	12621	
2015	614	0.40	PP	Yes	12622	
2063	629	0.78	CP	Yes	12623	

Target:	7056-T721			Date:	2/25/2015	
Plate Number:	936221			Location:	EF 108	
Thickness, in:	2.569					
Thickness, mm:	65.25					
Hardness, BHN:	146					
Obliquity:	0°					
Projectile:	0.50 cal APM2					
Velocity Measurement:	X-Ray					
V ₅₀ :	2882 ft/s	879 m/s	Number of Shots:		4	
Std Dev:	29 ft/s	9 m/s	Spread:		57 ft/s	17 m/s
ZMR:	N/A	N/A				
Striking Velocity		Gamma	Result (PP/CP)	Used for V ₅₀ (Yes/No)	Shot Number	Comments
(ft/s)	(m/s)	(deg)				
2698	822	0.53	PP	No	12555	
2751	838	1.47	PP	No	12556	
2910	887	0.97	CP	Yes	12557	
2853	870	0.41	PP	Yes	12558	
2861	872	0.83	PP	Yes	12559	
2904	885	1.03	CP	Yes	12560	

Target:	7056-T721			Date:	2/23/2015	
Plate Number:	936231			Location:	EF 108	
Thickness, in:	2.572					
Thickness, mm:	65.33					
Hardness, BHN:	153					
Obliquity:	0°					
Projectile:	0.50 cal APM2					
Velocity Measurement:	X-Ray					
V ₅₀ :	2809 ft/s	856 m/s	Number of Shots:		6	
Std Dev:	32 ft/s	10 m/s	Spread:		72 ft/s	22 m/s
ZMR:	N/A	N/A				
Striking Velocity		Gamma	Result (PP/CP)	Used for V ₅₀ (Yes/No)	Shot Number	Comments
(ft/s)	(m/s)	(deg)				
2899	884	0.71	CP	No	12548	
2841	866	0.99	CP	Yes	12549	
2769	844	0.32	PP	Yes	12550	
2773	845	0.47	PP	Yes	12551	
2830	863	0.72	CP	Yes	12552	
2835	864	1.18	CP	Yes	12553	
2807	856	0.23	PP	Yes	12554	

Target:	7056-T751			Date:	2/4/2015	
Plate Number:	933171			Location:	EF 108	
Thickness, in:	3.006					
Thickness, mm:	76.35					
Hardness, BHN:	149					
Obliquity:	0°					
Projectile:	0.50 cal APM2					
Velocity Measurement:	X-Ray					
V ₅₀ :	3121 ft/s	951 m/s	Number of Shots:		4	
Std Dev:	12 ft/s	4 m/s	Spread:		26 ft/s	8 m/s
ZMR:	N/A	N/A				
Striking Velocity		Gamma	Result (PP/CP)	Used for V ₅₀ (Yes/No)	Shot Number	Comments
(ft/s)	(m/s)	(deg)				
3038	926	0.29	PP	No	12518	
3135	956	0.34	CP	Yes	12519	
3065	934	1.22	PP	No	12520	
3109	948	0.77	PP	Yes	12521	
3222	982	0.92	CP	No	12522	
2705	824	0.49	PP	No	12523	
3213	979	1.22	CP	No	12524	
3177	968	0.50	CP	No	12525	
3125	952	0.70	CP	Yes	12526	
3114	949	0.67	PP	Yes	12527	

Target:	7056-T751			Date:	2/2/2015	
Plate Number:	933171			Location:	EF 108	
Thickness, in:	2.940					
Thickness, mm:	74.68					
Hardness, BHN:	153					
Obliquity:	0°					
Projectile:	0.50 cal APM2					
Velocity Measurement:	X-Ray					
V ₅₀ :	3102 ft/s	945 m/s	Number of Shots:		4	
Std Dev:	20 ft/s	6 m/s	Spread:		43 ft/s	13 m/s
ZMR:	N/A	N/A				
Striking Velocity		Gamma	Result (PP/CP)	Used for V ₅₀ (Yes/No)	Shot Number	Comments
(ft/s)	(m/s)	(deg)				
2996	913	0.70	PP	No	12510	
3022	921	0.88	PP	No	12511	
3186	971	0.97	CP	No	12512	
3101	945	0.84	CP	Yes	12513	
3070	936	0.48	PP	No	12514	
3089	941	0.79	PP	Yes	12515	
3088	941	0.72	PP	Yes	12516	
3131	954	1.01	CP	Yes	12517	

Target:	7056-T721			Date:	4/1/2015	
Plate Number:	649461			Location:	EF 108	
Thickness, in:	1.613					
Thickness, mm:	40.97					
Hardness, BHN:	143					
Obliquity:	0°					
Projectile:	0.50 cal APM2					
Velocity Measurement:	X-Ray					
V ₅₀ :	2167 ft/s	660 m/s	Number of Shots:		4	
Std Dev:	22 ft/s	7 m/s	Spread:		46 ft/s	14 m/s
ZMR:	N/A	N/A				
Striking Velocity		Gamma	Result (PP/CP)	Used for V ₅₀ (Yes/No)	Shot Number	Comments
(ft/s)	(m/s)	(deg)				
2183	665	1.45	CP	Yes	12624	
2094	638	1.04	PP	No	12625	
2160	658	0.58	PP	Yes	12626	
2186	666	0.42	CP	Yes	12627	
2140	652	0.70	PP	Yes	12628	

Target:	7056-T721			Date:	8/27/2015	
Plate Number:	900306			Location:	EF 108	
Thickness, in:	1.977					
Thickness, mm:	50.22					
Hardness, BHN:	153					
Obliquity:	0°					
Projectile:	0.50 cal APM2					
Velocity Measurement:	X-Ray					
V ₅₀ :	2473 ft/s	754 m/s	Number of Shots:		4	
Std Dev:	25 ft/s	8 m/s	Spread:		47 ft/s	15 m/s
ZMR:	N/A	N/A				
Striking Velocity		Gamma	Result (PP/CP)	Used for V ₅₀ (Yes/No)	Shot Number	Comments
(ft/s)	(m/s)	(deg)				
2496	761	0.65	CP	Yes	12938	
2420	738	0.72	PP	No	12939	
2449	746	0.15	PP	Yes	12940	
2453	748	0.70	PP	Yes	12941	
2493	760	0.59	CP	Yes	12942	

14.5-mm BS41

Target:		7056-T751		Date:		11/24/2014	
Plate Number:		933181		Location:		EF 106	
Thickness, in:		2.495					
Thickness, mm:		63.37					
Hardness, BHN:		156					
Obliquity:		0°					
Projectile:		14.5-mm BS41					
Velocity Measurement:		X-Ray					
V ₅₀ :		2686 ft/s	819 m/s	Number of Shots:		4	
Std Dev:		21 ft/s	7 m/s	Spread:		52 ft/s	16 m/s
ZMR:		N/A	N/A				
Striking Velocity		Gamma	Result (PP/CP)	Used for V ₅₀ (Yes/No)	Shot Number	Comments	
(ft/s)	(m/s)	(deg)					
2685	818	0.70	PP	Yes	14063		
2712	827	1.06	CP	Yes	14064		
2687	819	1.00	CP	Yes	14065		
2660	811	0.64	PP	Yes	14066		

Target:	7056-T751			Date:	11/20/2014	
Plate Number:	933181			Location:	EF 106	
Thickness, in:	2.443					
Thickness, mm:	62.05					
Hardness, BHN:	156					
Obliquity:	0°					
Projectile:	14.5-mm BS41					
Velocity Measurement:	X-Ray					
V ₅₀ :	2624 ft/s	800 m/s	Number of Shots:		4	
Std Dev:	21 ft/s	6 m/s	Spread:		49 ft/s	15 m/s
ZMR:	N/A	N/A				
Striking Velocity		Gamma	Result (PP/CP)	Used for V ₅₀ (Yes/No)	Shot Number	Comments
(ft/s)	(m/s)	(deg)				
2569	783	0.69	PP	No	14056	
2698	822	0.65	CP	No	14057	
2648	807	1.55	CP	Yes	14058	
2584	788	0.78	PP	No	14059	
2633	802	0.56	CP	Yes	14060	
2599	792	0.73	PP	Yes	14061	
2615	797	0.99	PP	Yes	14062	

Target:	7056-T751			Date:	12/1/2014	
Plate Number:	933171			Location:	EF 106	
Thickness, in:	2.940					
Thickness, mm:	74.68					
Hardness, BHN:	153					
Obliquity:	0°					
Projectile:	14.5-mm BS41					
Velocity Measurement:	X-Ray					
V ₅₀ :	2866 ft/s	873 m/s	Number of Shots:		4	
Std Dev:	25 ft/s	8 m/s	Spread:		46 ft/s	14 m/s
ZMR:	N/A	N/A				
Striking Velocity		Gamma	Result (PP/CP)	Used for V ₅₀ (Yes/No)	Shot Number	Comments
(ft/s)	(m/s)	(deg)				
3108	947	0.60	CP	No	14067	
3028	923	3.20	CP	No	14068	High Yaw
2996	913	1.39	CP	No	14069	
2888	880	1.57	CP	Yes	14070	
2786	849	0.79	PP	No	14071	
2804	855	0.78	PP	No	14072	
2842	866	1.39	PP	Yes	14073	
2846	867	1.12	PP	Yes	14074	
2888	880	1.16	CP	Yes	14075	

Target:	7056-T751			Date:	12/4/2014	
Plate Number:	933171			Location:	EF 106	
Thickness, in:	3.006					
Thickness, mm:	76.35					
Hardness, BHN:	149					
Obliquity:	0°					
Projectile:	14.5-mm BS41					
Velocity Measurement:	X-Ray					
V ₅₀ :	2932 ft/s	894 m/s	Number of Shots:		4	
Std Dev:	20 ft/s	6 m/s	Spread:		41 ft/s	13 m/s
ZMR:	N/A	N/A				
Striking Velocity		Gamma	Result (PP/CP)	Used for V ₅₀ (Yes/No)	Shot Number	Comments
(ft/s)	(m/s)	(deg)				
2914	888	1.56	PP	Yes	14076	
2955	901	1.75	CP	Yes	17077	
2941	896	0.75	CP	Yes	20078	
2917	889	1.59	PP	Yes	23079	

Target:	7056-T721			Date:	3/10/2015	
Plate Number:	936221			Location:	EF 106	
Thickness, in:	2.569					
Thickness, mm:	65.25					
Hardness, BHN:	146					
Obliquity:	0°					
Projectile:	14.5-mm BS41					
Velocity Measurement:	Chrono					
V ₅₀ :	2652 ft/s	809 m/s	Number of Shots:		4	
Std Dev:	11 ft/s	3 m/s	Spread:		25 ft/s	8 m/s
ZMR:	N/A	N/A				
Striking Velocity		Gamma	Result (PP/CP)	Used for V ₅₀ (Yes/No)	Shot Number	Comments
(ft/s)	(m/s)	(deg)				
2647	807	--	PP	Yes	14218	
2666	813	--	CP	Yes	14219	
2641	805	--	PP	Yes	14220	
2655	809	--	CP	Yes	14221	

Target:	7056-T721			Date:	3/11/2015	
Plate Number:	936231			Location:	EF 106	
Thickness, in:	2.572					
Thickness, mm:	65.33					
Hardness, BHN:	153					
Obliquity:	0°					
Projectile:	14.5-mm BS41					
Velocity Measurement:	Chrono					
V ₅₀ :	2680 ft/s	817 m/s	Number of Shots:		4	
Std Dev:	19 ft/s	6 m/s	Spread:		43 ft/s	13 m/s
ZMR:	N/A	N/A				
Striking Velocity		Gamma	Result (PP/CP)	Used for V ₅₀ (Yes/No)	Shot Number	Comments
(ft/s)	(m/s)	(deg)				
2625	800	--	PP	No	14222	
2653	809	--	PP	Yes	14223	
2687	819	--	CP	Yes	14224	
2683	818	--	PP	Yes	14225	
2696	822	--	CP	Yes	14226	

0.50-cal FSP

Target:	7056-T751			Date:	9/24/2014	
Plate Number:	647911			Location:	EF 106	
Thickness, in:	0.900					
Thickness, mm:	22.86					
Hardness, BHN:	159					
Obliquity:	0°					
Projectile:	0.50-cal FSP					
Velocity Measurement:	Chronograph					
V ₅₀ :	2623 ft/s	799 m/s	Number of Shots:		10	
Std Dev:	60 ft/s	18 m/s	Spread:		187 ft/s	57 m/s
ZMR:	187 ft/s	57 m/s				
Striking Velocity		Gamma	Result (PP/CP)	Used for V ₅₀ (Yes/No)	Shot Number	Comments
(ft/s)	(m/s)	(deg)				
2603	793	--	CP	Yes	13858	
2451	747	--	PP	No	13859	
2468	752	--	PP	No	13860	
2503	763	--	CP	Yes	13861	
2501	762	--	PP	No	13862	
2521	768	--	PP	No	13863	
2510	765	--	PP	No	13864	
2539	774	--	PP	No	13865	
2550	777	--	PP	No	13866	
2563	781	--	PP	Yes	13867	
2604	794	--	PP	Yes	13868	
2690	820	--	CP	Yes	13869	
2623	799	--	CP	Yes	13870	
2615	797	--	PP	Yes	13871	
2648	807	--	PP	Yes	13872	
2690	820	--	PP	Yes	13873	
2686	819	--	CP	Yes	13874	

Target:	7056-T751			Date:	12/17/2014	
Plate Number:	647911			Location:	EF 106	
Thickness, in:	1.024					
Thickness, mm:	26.01					
Hardness, BHN:	156					
Obliquity:	0°					
Projectile:	0.50-cal FSP					
Velocity Measurement:	Chronograph					
V ₅₀ :	3607 ft/s	1100 m/s	Number of Shots:		4	
Std Dev:	18 ft/s	5 m/s	Spread:		36 ft/s	11 m/s
ZMR:	24 ft/s	7 m/s				
Striking Velocity		Gamma	Result (PP/CP)	Used for V ₅₀ (Yes/No)	Shot Number	Comments
(ft/s)	(m/s)	(deg)				
3249	990	--	PP	No		
3308	1008	--	PP	No		
3593	1095	--	PP	Yes		
3902	1189	--	CP	No		
3505	1068	--	PP	No		
3881	1183	--	CP	No		
3764	1147	--	CP	No		
3848	1173	--	CP	No		
3675	1120	--	CP	No		
3592	1095	--	CP	Yes		
3628	1106	--	CP	Yes		
3649	1112	--	CP	No		
3547	1081	--	PP	No		
3616	1102	--	PP	Yes		

Target:	7056-T721			Date:	1/7/2015	
Plate Number:	649471			Location:	EF 106	
Thickness, in:	0.894					
Thickness, mm:	22.71					
Hardness, BHN:	153					
Obliquity:	0°					
Projectile:	0.50-cal FSP					
Velocity Measurement:	Chronograph					
V ₅₀ :	3140 ft/s	957 m/s	Number of Shots:		4	
Std Dev:	18 ft/s	5 m/s	Spread:		42 ft/s	13 m/s
ZMR:	N/A	N/A				
Striking Velocity		Gamma	Result (PP/CP)	Used for V ₅₀ (Yes/No)	Shot Number	Comments
(ft/s)	(m/s)	(deg)				
2559	780	--	PP	No	14112	
2823	860	--	PP	No	14113	
3211	979	--	CP	No	14114	
3021	921	--	PP	No	14115	
3163	964	--	CP	Yes	14116	
3133	955	--	PP	Yes	14117	
3170	966	--	CP	No	14118	
3141	957	--	CP	Yes	14119	
3121	951	--	PP	Yes	14120	

20-mm FSP

Target:		7056-T751		Date:		10/22/2014	
Plate Number:		647921		Location:		EF 108	
Thickness, in:		1.638					
Thickness, mm:		41.61					
Hardness, BHN:		156					
Obliquity:		0°					
Projectile:		20-mm FSP					
Velocity Measurement:		Chronograph					
V ₅₀ :		3319 ft/s	1012 m/s	Number of Shots:		4	
Std Dev:		8 ft/s	2 m/s	Spread:		17 ft/s	5 m/s
ZMR:		N/A	N/A				
Striking Velocity		Gamma	Result (PP/CP)	Used for V ₅₀ (Yes/No)	Shot Number	Comments	
(ft/s)	(m/s)	(deg)					
3323	1013	--	PP	Yes	12355		
3419	1042	--	CP	No	12356		
3373	1028	--	CP	No	12357		
3328	1014	--	CP	Yes	12358		
3314	1010	--	CP	Yes	12359		
3311	1009	--	PP	Yes	12360		

Target:	7056-T751			Date:	10/24/2014	
Plate Number:	647921			Location:	EF 108	
Thickness, in:	1.449					
Thickness, mm:	36.80					
Hardness, BHN:	166					
Obliquity:	0°					
Projectile:	20-mm FSP					
Velocity Measurement:	Chronograph					
V ₅₀ :	2479 ft/s	756 m/s	Number of Shots:		6	
Std Dev:	35 ft/s	11 m/s	Spread:		84 ft/s	26 m/s
ZMR:	26 ft/s	8 m/s				
Striking Velocity		Gamma	Result (PP/CP)	Used for V ₅₀ (Yes/No)	Shot Number	Comments
(ft/s)	(m/s)	(deg)				
2568	783	--	CP	No	12361	
2506	764	--	PP	Yes	12362	
2586	788	--	CP	No	12363	
2543	775	--	CP	No	12364	
2528	770	--	CP	No	12365	
2521	768	--	CP	No	12366	
2541	774	--	CP	No	12367	
2494	760	--	CP	Yes	12368	
2480	756	--	CP	Yes	12369	
2629	801	--	CP	No	12370	
2520	768	--	CP	Yes	12371	
2437	743	--	PP	Yes	12372	
2436	742	--	PP	Yes	12373	

Target:	7056-T751			Date:	10/29/2014	
Plate Number:	647911			Location:	EF 108	
Thickness, in:	0.900					
Thickness, mm:	22.86					
Hardness, BHN:	159					
Obliquity:	0°					
Projectile:	20-mm FSP					
Velocity Measurement:	Chronograph					
V ₅₀ :	1294 ft/s	394 m/s	Number of Shots:		4	
Std Dev:	25 ft/s	8 m/s	Spread:		59 ft/s	18 m/s
ZMR:	N/A	N/A				
Striking Velocity		Gamma	Result (PP/CP)	Used for V ₅₀ (Yes/No)	Shot Number	Comments
(ft/s)	(m/s)	(deg)				
1384	422	--	CP	No	12378	
1330	405	--	CP	Yes	12379	
1284	391	--	PP	Yes	12380	
1292	394	--	CP	Yes	12381	
1271	387	--	PP	Yes	12382	

Target:	7056-T751			Date:	10/28/2014	
Plate Number:	647911			Location:	EF 108	
Thickness, in:	1.024					
Thickness, mm:	26.01					
Hardness, BHN:	156					
Obliquity:	0°					
Projectile:	20-mm FSP					
Velocity Measurement:	Chronograph					
V ₅₀ :	1495 ft/s	456 m/s	Number of Shots:		4	
Std Dev:	21 ft/s	6 m/s	Spread:		50 ft/s	15 m/s
ZMR:	N/A	N/A				
Striking Velocity		Gamma	Result (PP/CP)	Used for V ₅₀ (Yes/No)	Shot Number	Comments
(ft/s)	(m/s)	(deg)				
1522	464	--	CP	Yes	12374	
1472	449	--	PP	Yes	12375	
1486	453	--	PP	Yes	12376	
1500	457	--	CP	Yes	12377	

Target:	7056-T721			Date:	3/30/2015	
Plate Number:	649471			Location:	EF 106	
Thickness, in:	0.892					
Thickness, mm:	22.66					
Hardness, BHN:	153					
Obliquity:	0°					
Projectile:	20-mm FSP					
Velocity Measurement:	X-ray					
V ₅₀ :	1329 ft/s	405 m/s	Number of Shots:		4	
Std Dev:	23 ft/s	7 m/s	Spread:		55 ft/s	17 m/s
ZMR:	7 ft/s	2 m/s				
Striking Velocity		Gamma	Result (PP/CP)	Used for V ₅₀ (Yes/No)	Shot Number	Comments
(ft/s)	(m/s)	(deg)				
1417	432	0.30	CP	No	14251	
1322	403	1.83	CP	Yes	14252	
1236	377	0.86	PP	No	14253	
1256	383	0.70	PP	No	14254	
--	--	--	PP	No	14255	missed x-ray
1286	392	1.44	PP	No	14256	
1305	398	0.69	PP	Yes	14257	
1329	405	0.34	PP	Yes	14258	
1360	415	1.75	CP	Yes	14259	

Target:	7056-T721			Date:	3/23/2015	
Plate Number:	649461			Location:	EF 106	
Thickness, in:	1.445					
Thickness, mm:	36.70					
Hardness, BHN:	143					
Obliquity:	0°					
Projectile:	20-mm FSP					
Velocity Measurement:	X-ray					
V ₅₀ :	2868 ft/s	874 m/s	Number of Shots:		4	
Std Dev:	22 ft/s	7 m/s	Spread:		49 ft/s	15 m/s
ZMR:	N/A	N/A				
Striking Velocity		Gamma	Result (PP/CP)	Used for V ₅₀ (Yes/No)	Shot Number	Comments
(ft/s)	(m/s)	(deg)				
2544	775	1.23	PP	No	14241	
2613	796	1.08	PP	No	14242	
2672	814	0.77	PP	No	14243	
2768	844	0.51	PP	No	14244	
2835	864	0.67	PP	Yes	14245	
2877	877	0.46	CP	Yes	14246	
2874	876	0.56	PP	Yes	14247	
2819	859	0.89	PP	No	14248	
--	--	--	CP	No	14249	missed x-ray
2884	879	0.98	CP	Yes	14250	

Target:	7056-T721			Date:	2/19/2015	
Plate Number:	649461			Location:	EF 106	
Thickness, in:	1.613					
Thickness, mm:	40.97					
Hardness, BHN:	143					
Obliquity:	0°					
Projectile:	20-mm FSP					
Velocity Measurement:	X-ray					
V ₅₀ :	3376 ft/s	1029 m/s	Number of Shots:		4	
Std Dev:	27 ft/s	8 m/s	Spread:		55 ft/s	17 m/s
ZMR:	N/A	N/A				
Striking Velocity		Gamma	Result (PP/CP)	Used for V ₅₀ (Yes/No)	Shot Number	Comments
(ft/s)	(m/s)	(deg)				
3237	987	0.40	PP	No	14191	
3468	1057	1.93	CP	No	14192	
3256	992	0.56	PP	No	14193	
3292	1003	0.55	PP	No	14194	
3353	1022	1.55	PP	Yes	14195	
3388	1033	0.55	CP	Yes	14196	
3353	1022	0.57	PP	Yes	14197	
3455	1053	0.18	CP	No	14198	
3408	1039	0.66	CP	Yes	14199	

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List of Symbols, Abbreviations, and Acronyms

AA	aluminum alloy
Al	aluminum
AP	armor-piercing
ARL	US Army Research Laboratory
CP	complete penetration
EF	experimental facility
FSP	fragment-simulating projectile
ID	identification
IR	infrared
mil-spec	military specification
PP	partial penetration

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